ALLEN CAREER INSTITUTE
KOTA (RAJASTHAN)
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PHYSICS

JEE (MAIN+ADVANCED)

ENTHUSIAST COURSE

EXERCISE

Electrostatics

English Medium

EXERCISE (O-1)

SINGLE CORRECT TYPE QUESTIONS

A. Coulomb's Law

1. If an object made of substance A rubs an object made of substance B, then A becomes positively charged and B becomes negatively charged. If, however, an object made of substance A is rubbed against an object made of substance C, then A becomes negatively charged. What will happen if an object made of substance B is rubbed against an object made of substance C?

(A) B becomes positively charged and C becomes positively charged.

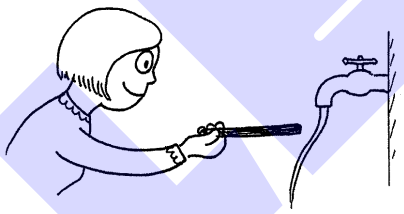
(B) B becomes positively charged and C becomes negatively charged.

(C) B becomes negatively charged and C becomes positively charged.

(D) B becomes negatively charged and C becomes negatively charged.

ES0056

2. In normal cases thin stream of water bends toward a negatively charged rod. When a positively charged rod is placed near the stream, it will bend in the



(A) Opposite direction.

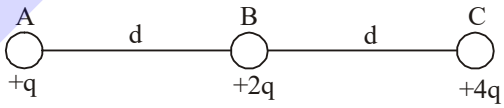
(B) Same direction.

(C) It won't bend at all.

(D) Can't be predicted.

ES0057

3. Three charges +q, +2q and +4q are connected by strings as shown in the figure. What is ratio of tensions in the strings AB and BC.



(A) 1 : 2

(B) 1 : 3

(C) 2 : 1

(D) 3 : 1

ES0063

4. A total charge Q is broken in two parts Q_1 and Q_2 and they are placed at a distance R from each other. The maximum force of repulsion between them will occur, when

(A) $Q_2 = \frac{Q}{R}, Q_1 = Q - \frac{Q}{R}$

(B) $Q_2 = \frac{Q}{4}, Q_1 = Q - \frac{2Q}{3}$

(C) $Q_2 = \frac{Q}{4}, Q_1 = \frac{3Q}{4}$

(D) $Q_1 = \frac{Q}{2}, Q_2 = \frac{Q}{2}$

ES0296

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5. Three charges 4q, Q and q are in a straight line in the position of 0, $\ell/2$ and ℓ respectively. The resultant force on q will be zero, if Q =

(A) $-q$ (B) $-2q$ (C) $-\frac{q}{2}$ (D) $4q$

ES0297

6. A charge q_1 exerts some force on a second charge q_2. If third charge q_3 is brought near, the force of q_1 exerted on q_2

(A) Decreases

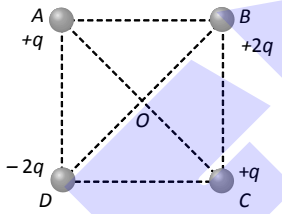
(B) Increases

(C) Remains unchanged

(D) Increases if q_3 is of the same sign as q_1 and decreases if q_3 is of opposite sign

ES0298

7. Four charges are arranged at the corners of a square ABCD, as shown in the adjoining figure. The force on the charge kept at the centre O is

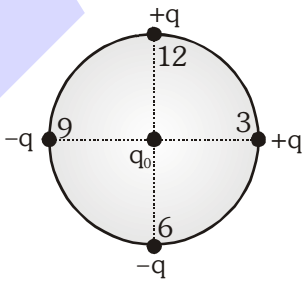


(A) Zero (B) Along the diagonal AC

(C) Along the diagonal BD (D) Perpendicular to side AB

ES0299

8. Four charges are placed at the circumference of a dial clock as shown in figure. If the clock has only hour hand, then the resultant force on a charge q_0 placed at the centre, points in the direction which shows the time as :



(A) 1:30 (B) 7:30 (C) 4:30 (D) 10:30

ES0300

9. A glass rod is rubbed with silk. It acquires positive charge because

(A) protons are added to it

(B) electrons are removed from it

(C) electrons are added to it

(D) some positively charged particles are added to it

ES0301

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10. Conservation of electric charge implies that
(A) charge exists on particles
(B) charge cannot be destroyed
(C) simultaneous creation of equal and opposite charges is permissible
(D) the number of charged particles in the universe is constant.

ES0302

11. Quantization of charge implies
(A) charge exists on particles
(B) there is a minimum permissible magnitude of charge
(C) charge, which is a fraction of coulomb is not possible
(D) none of the above

ES0303

12. The minimum amount of charge observed so far is

(A) 1C (B) $4.8\times10^{-13}C$

(C) $1.6\times10^{-19}C$ (D) none of the above

ES0304

13. A positively charged glass rod is brought near the disc of uncharged gold leaf electroscope. The leaves diverge. Which of the following statements is correct
(A) No charge is present on the leaves
(B) Positive charge is induced on the leaves
(C) Negative charge is induced on the leaves
(D) Positive charge is induced on one leave and negative charge is induced on the other leave.

ES0305

14. The dielectric constant of an insulator cannot be
(A) 1.5 (B) 3 (C) 4.5 (D) ∞

ES0306

15. The ratio of the force between two charges in vacuum at a certain distance apart to that between the same charges, the same distance apart in a medium of permittivity ε is
(A) $\varepsilon:1$ (B) $1:\varepsilon$ (C) $\varepsilon_0:\varepsilon$ (D) none of the above

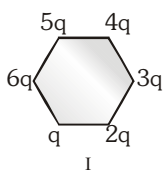
ES0307

16. Five balls numbered 1 to 5 are suspended using separate threads. Pairs (1,2), (2,4), (4,1) show electrostatic attraction, while pairs (2,3) and (4,5) show repulsion. Therefore, ball 1 must be
(A) positively charged (B) negatively charged
(C) neutral (D) made of metal

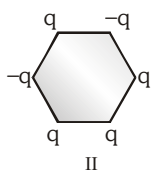
ES0308

B. Electric Field

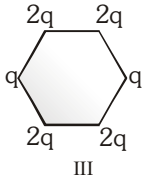
17. Figures below show regular hexagon, the charges are placed at the vertices. In which of the following cases the electric field at the centre is zero.



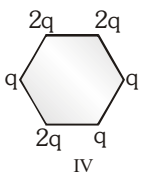
I



II



III



IV

(A) IV (B) III (C) I (D) II

ES0309

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18. Five positive equal charges are placed at vertices of a regular hexagon and net electric field at the centre is E_1. A negative charge having equal magnitude is placed sixth vertex and then net electric field is E_2. Find $\frac{E_2}{E_1}$.

(A) 2 (B) 1 (C) 3 (D) None of these

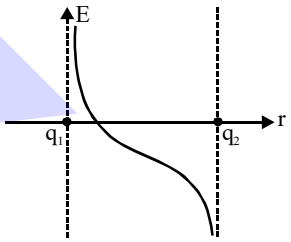
ES0061

19. Equal charges q are placed at the four corners A, B, C, D of a square of length a. The magnitude of the force on the charge at B will be

(A) $\frac{3q^2}{4\pi\varepsilon_0 a^2}$ (B) $\frac{4q^2}{4\pi\varepsilon_0 a^2}$ (C) $\left(\frac{1+2\sqrt{2}}{2}\right)\frac{q^2}{4\pi\varepsilon_0 a^2}$ (D) $\left(2+\frac{1}{\sqrt{2}}\right)\frac{q^2}{4\pi\varepsilon_0 a^2}$

ES0310

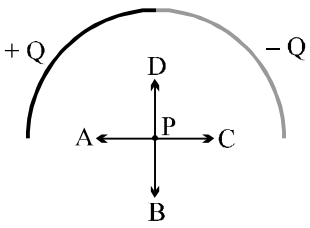
20. The variation of electric field between the two charges q_1 and q_2 along the line joining the charges is plotted against distance from q_1 (taking rightward direction of electric field as positive) as shown in the figure. Then the correct statement is :-



(A) q_1 and q_2 are positive and $q_1 < q_2$
(B) q_1 and q_2 are positive and $q_1 > q_2$
(C) q_1 is positive and q_2 is negative and $q_1 < q_2$
(D) q_1 and q_2 are negative and $q_1 < q_2$

ES0064

21. As shown in the figure, an insulating rod is set into the shape of a semicircle. The left half of the rod has a charge of + Q uniformly distributed along its length, and the right half of the rod has a charge of –Q uniformly distributed along its length. What vector shows the correct direction of the electric field at point P, the centre of the semicircle ?



(A) A (B) B
(C) C (D) D

ES0069

22. An electron having charge 'e' and mass 'm' is moving in a uniform electric field E(neglect gravity). Its magnitude of acceleration will be

(A) $\frac{e^2}{m}$ (B) $\frac{E^2 e}{m}$ (C) $\frac{eE}{m}$ (D) $\frac{mE}{e}$

ES0311

23. The electric field strength due to a circular loop of charge of radius R and linear density of charge λ at its centre is proportional to

(A) λR (B) $\frac{\lambda}{R}$ (C) $\frac{\lambda}{R^2}$ (D) none of the above

ES0312

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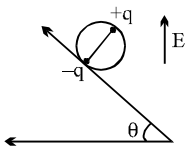
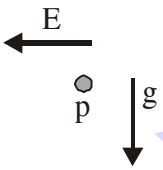
24. A wheel having mass m has charges +q and –q on diametrically opposite points. It remains in equilibrium on a rough inclined plane in the presence of uniform vertical electric field E =

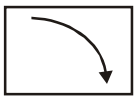
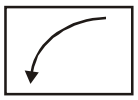
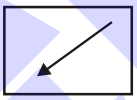
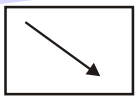


(A) $\frac{mg}{q}$ (B) $\frac{mg}{2q}$ (C) $\frac{mg\tan\theta}{2q}$ (D) none

ES0075

25. A negatively charged particle *p* is placed, initially at rest, in a constant, uniform gravitational field and a constant, uniform electric field as shown in the diagram. What qualitatively, is the shape of the trajectory of the electron ?



(A)  (B)  (C)  (D) 

ES0076

26. The electric field strength due to a ring of radius R at a distance x from its centre on the axis of ring carrying charge Q is given by

$$E = \frac{1}{4\pi\varepsilon_0}\frac{Qx}{(R^2+x^2)^{3/2}}$$

At what distance from the centre will the electric field be maximum ?

(A) $x = R$ (B) $x = R/2$ (C) $x = R/\sqrt{2}$ (D) $x = \sqrt{2}R$

ES0313

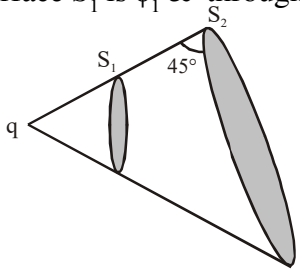
C. Electric Flux

27. A sphere of radius R and charge Q is placed inside an imaginary sphere of radius 2R whose centre coincides with the given sphere. The flux related to imaginary sphere is :

(A) $\frac{Q}{\epsilon_0}$ (B) $\frac{Q}{2\epsilon_0}$ (C) $\frac{4Q}{\epsilon_0}$ (D) $\frac{2Q}{\epsilon_0}$

ES0314

28. In the given figure flux through surface S_1 is ϕ_1 & through S_2 is ϕ_2. Which is correct ?



(A) $\phi_1 = \phi_2$ (B) $\phi_1 > \phi_2$ (C) $\phi_1 < \phi_2$ (D) None of these

ES0079

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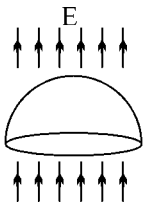
29. A hemispherical surface (half of a spherical surface) of radius R is located in a uniform electric field E that is parallel to the axis of the hemisphere. What is the magnitude of the electric flux through the hemisphere surface?



(A) 0 (B) $4\pi R^2E/3$

(C) $2\pi R^2E$ (D) πR^2E

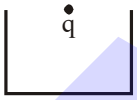
ES0080

30. An electric charge q is placed at the centre of a cube of side α. The electric flux on one of its faces will be

(A) $\frac{q}{6\varepsilon_0}$ (B) $\frac{q}{\varepsilon_0 a^2}$ (C) $\frac{q}{4\pi\varepsilon_0 a^2}$ (D) $\frac{q}{\varepsilon_0}$

ES0315

31. A charge q is placed at the centre of the open end of a cylindrical vessel (figure). The flux of the electric field through the surface of the vessel is



(A) zero (B) q/ε_0 (C) $q/2\varepsilon_0$ (D) $4q/\varepsilon_0$

ES0316

32. For a given surface the Gauss's law is stated as $\oint \vec{E}\cdot\vec{ds} = 0$. From this we can conclude that

(A) $\vec{E}$ is necessarily zero on the surface

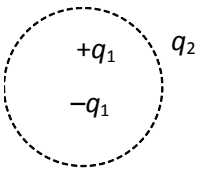
(B) $\vec{E}$ is perpendicular to the surface at every point

(C) The total flux through the surface is zero

(D) The flux is only going out of the surface

ES0317

33. Consider the charge configuration and spherical Gaussian surface as shown in the figure. When calculating the flux of the electric field over the spherical surface the electric field will be due to



(A) q_2

(B) Only the positive charges

(C) $+q_1$ and $-q_1$

(D) All the charges

ES0318

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34. The electric field in a region is given by $\vec{E} = 200\hat{i}$ N/C for x > 0 and $-200\hat{i}$ N/C for x < 0. A closed cylinder of length 2m and cross-section area 10^2 m^2 is kept in such a way that the axis of cylinder is along X-axis and its centre coincides with origin. The total charge inside the cylinder is
[Take : $\varepsilon_0 = 8.85 \times 10^{-12}$ C^{2}m^2.N)
(A) 0 (B) 1.86×10^{-5}C (C) 1.77×10^{-11}C (D) 35.4×10^{-8} C

ES0086

35. Consider a circle of radius R. A point charge lies at a distance 'a' from its center and on its axis such that $R = a\sqrt{3}$. If electric flux passing through the circle is ϕ then the magnitude of the point charge is:-

(A) $\sqrt{3}\varepsilon_0\phi$ (B) $2\varepsilon_0\phi$ (C) $4\varepsilon_0\phi/\sqrt{3}$ (D) $4\ \varepsilon_0\phi$

ES0089

D. Electric Potential Energy

36. Two positively charged particles X and Y are initially far away from each other and at rest. X begins to move towards Y with some initial velocity. The total momentum and energy of the system are p and E.
(A) If Y is fixed, both p and E are conserved.
(B) If Y is fixed, E is conserved, but not p.
(C) If both are free to move, p is conserved but not E.
(D) If both are free, E is conserved, but not p.

ES0091

37. When the separation between two charges is increased, the electric potential energy of the charges
(A) increases (B) decreases
(C) remains the same (D) may increase or decrease

ES0319

38. If a positive charge be moved against the electric field, then
(A) energy of the system will decrease
(B) energy will be used from an outside source
(C) work will be done by the field
(D) the intensity of the field will decrease

ES0320

39. A point charge q is rotated along a circle in the electric field generated by another point charge Q. The work done by the electric field on the rotating charge in one complete revolution is
(A) zero
(B) positive
(C) negative
(D) zero if the charge Q is at the centre and nonzero otherwise

ES0321

40. A ring of radius R carries a charge +q. A test charge $-q_0$ is released on its axis at a distance $\sqrt{3}R$ from its centre. How much kinetic energy will be acquired by the test charge when it reaches the centre of the ring ?

(A) $\frac{1}{4\pi\varepsilon_0}\frac{qq_0}{R}$ (B) $\frac{1}{4\pi\varepsilon_0}\frac{qq_0}{2R}$ (C) $\frac{1}{4\pi\varepsilon_0}\frac{qq_0}{\sqrt{3}R}$ (D) $\frac{1}{4\pi\varepsilon_0}\frac{qq_0}{3R}$

ES0322

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41. A proton and an electron are released infinite distance apart and then attracted towards each other. Which of the following statements about their kinetic energy is true ?
(A) Kinetic energy of electron is more than that of proton
(B) Kinetic energy of electron is less than that of proton
(C) Kinetic energy of electron = kinetic energy of proton
(D) None of the above is true as it depends on the distance between the particles.

ES0323

E. Electric Potential

42. Potential energy of a system comprising of point charges is U_1.When a charge q is added in the system without disturbing other charges, the potential energy becomes U_2.The potential of the point where the charge q is placed in the system is

(A) $\frac{U_2 - U_1}{q}$ (B) $\frac{U_1 - U_2}{q}$ (C) $\frac{U_1 + U_2}{2q}$ (D) $\frac{U_2 - U_1}{2q}$

ES0092

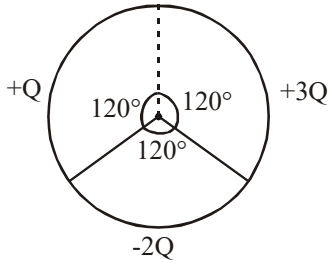
43. Three charges 2q, –q, –q are located at the vertices of an equilateral triangle. At the centre of the triangle
(A) The field is zero but potential is non-zero
(B) The field is non-zero but potential is zero
(C) Both field and potential are zero
(D) Both field and potential are non-zero

ES0324

44. The electric potential V is given as a function of distance × (metre) by $V = (5x^2 + 10x - 9)$ volt. Magnitude of electric field at x = 1 is
(A) 20 V/m (B) 6 V/m (C) 11 V/m (D) +23 V/m

ES0325

45. Figure shows three circular arcs, each of radius R and total charge as indicated. The net electric potential at the centre of curvature is :-



(A) $\frac{Q}{4\pi \in_0 R}$ (B) $\frac{Q}{2\pi \in_0 R}$

(C) $\frac{2Q}{\pi \in_0 R}$ (D) $\frac{Q}{\pi \in_0 R}$

ES0095

46. A solid sphere of radius R is charged uniformly. At what distance from its surface is the electrostatic potential half of the potential at the centre?
(A) R (B) R/2 (C) R/3 (D) 2R

ES0097

47. Electric potential at any point is $V = -5x + 3y + \sqrt{15}z$, then the magnitude of the electric field is
(A) $3\sqrt{2}$ (B) $4\sqrt{2}$ (C) $5\sqrt{2}$ (D) 7

ES0326

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48. A particle A has charge $+q$ and a particle B has charge $+4q$ with each of them having the same mass m. When allowed to fall from rest through the same electric potential difference, the ratio of their speed $\frac{v_A}{v_B}$ will become

(A) $2:1$ (B) $1:2$ (C) $1:4$ (D) $4:1$

ES0327

49. Work done in moving a positive charge on an equipotential surface is

(A) Finite, positive but not zero (B) Finite, negative but not zero

(C) Zero (D) Infinite

ES0328

50. A charge 3 coulomb experiences a force 300 N when placed in a uniform electric field. The potential difference between two points separated by a distance of 10 cm along the field line is :

(A) 10 V (B) 90 V (C) 1000 V (D) 9000 V

ES0329

51. An external agency carries $-5C$ of charge from infinity to a point in an electrostatic field and performs 100 Joules of work. The potential at the given point is

(A) + 10 V (B) – 10 V (C) + 20 V (D) – 20 V

ES0330

52. A Gaussian surface encloses no charge. Which of the following is true for a point inside it ?

(A) Electric field must be zero

(B) Electric potential must be zero

(C) Both electric field and potential must be zero

(D) none of the above

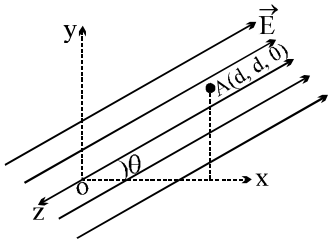
ES0331

53. Equipotential at a great distance from a collection of charges whose total sum is not zero are approximately

(A) spheres. (B) planes. (C) paraboloids (D) ellipsoids.

ES0101

54. A uniform electric field having strength $\vec{E}$ is existing in x-y plane as shown in figure. Find the p.d. between origin O & A(d, d, 0)



(A) Ed (cosθ + sinθ) (B) –Ed (sinθ – cosθ) (C) $\sqrt{2}$ Ed (D) none of these

ES0105

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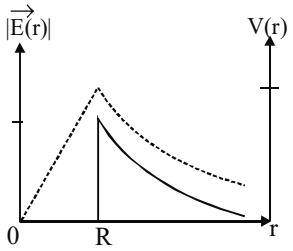
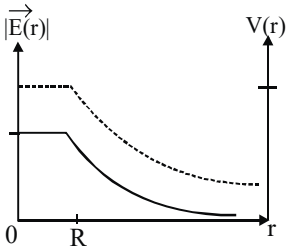
55. Consider a thin spherical shell of radius R with its centre at the origin, carrying uniform positive surface charge density. The variation of the magnitude of the electric field $|\vec{E}(r)|$ and the electric potential V(r) with the distance r from the centre, is best represented by which graph?

[IIT-JEE 2012]

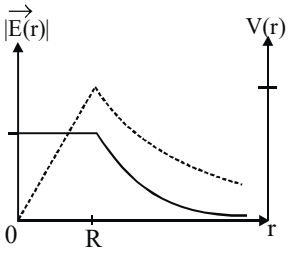
(A)



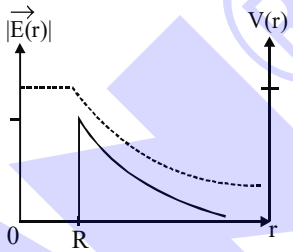
(B)



(C)



(D)



ES0215

F. Dipole

56. The electric field due to a dipole at a distance r on its axis is

(A) Directly proportional to r^3 (B) Inversely proportional to r^3

(C) Directly proportional to r^2 (D) Inversely proportional to r^2

ES0332

57. Electric charges q, q, –2q are placed at the corners of an equilateral triangle ABC of side *l*. The magnitude of electric dipole moment of the system is

(A) q*l* (B) 2q*l* (C) $\sqrt{3}$ q*l* (D) 4q*l*

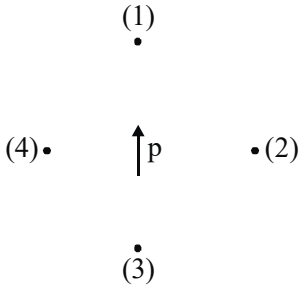
ES0333

58. If the magnitude of intensity of electric field at a distance x on axial line and at a distance y on equatorial line on a given dipole are equal, then x : y is

(A) 1 : 1 (B) $1:\sqrt{2}$ (C) 1 : 2 (D) $\sqrt[3]{2}:1$

ES0334

59. The drawing shows four points surrounding an electric dipole. Which one of the following expressions best ranks the electric potential at these four locations?



(A) 1 > 2 = 4 > 3 (B) 3 > 2 > 4 > 1 (C) 3 > 2 = 4 > 1 (D) 2 = 4 > 1 = 3

ES0109

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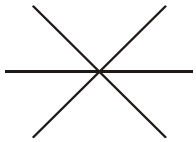
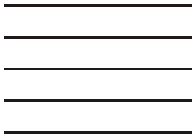
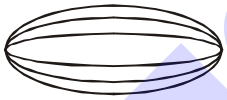
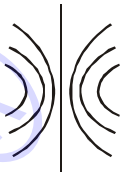
60. An electric dipole of moment $\vec{P}$ placed in a uniform electric field $\vec{E}$ has minimum potential energy when the angle between $\vec{P}$ and $\vec{E}$ is

(A) Zero (B) $\frac{\pi}{2}$ (C) π (D) None of these

ES0335

61. Which of the following represents the equipotential lines of a dipole (two equal and opposite charges placed at small separation)?

(A)  (B)  (C)  (D) 

ES0110

62. An electric dipole of moment $\vec{p}$ is placed normal to the lines of force of electric intensity $\vec{E}$, then the work done in deflecting it through an angle of $180°$ is

(A) pE (B) $+2pE$ (C) $-2pE$ (D) Zero

ES0336

63. An electric dipole (dipole moment p) is placed at a radial distance r >> a (where a is dipole length) from a infinite line of charge having linear charge density +λ. Dipole moment vector is aligned along radial vector $\vec{r}$ force experienced by dipole is :-

(A) $\frac{\lambda p}{2\pi\varepsilon_0 r^2}$, attractive (B) $\frac{\lambda p}{2\pi\varepsilon_0 r^3}$, attractive (C) $\frac{\lambda p}{2\pi\varepsilon_0 r^2}$, repulsive (D) $\frac{\lambda p}{2\pi\varepsilon_0 r^3}$, repulsive

ES0116

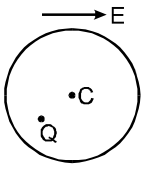
G. Conductors

64. Two hollow concentric conducting spheres of radii 2cm and 4 cm are given 2C and 4C charges respectively. The ratio of total charge on outer surface of outer sphere before and after they are connected by a conducting wire is :

(A) 2/3 (B) 1 (C) ∞ (D) 0

ES0337

65. A positive point charge Q is kept (as shown in the figure) inside a neutral conducting shell whose centre is at C. An external uniform electric field E is applied. Then :



(A) Force on Q due to E is zero

(B) Net force on Q is zero

(C) Net force acting on Q and conducting shell considered as a system is zero

(D) Net force acting on the shell due to E is zero.

ES0338

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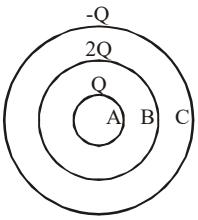
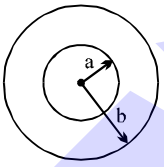
66. Charge Q, 2Q and –Q are given to three concentric conducting spherical shells A, B and C respectively. The ratio of charges on the inner and the outer surfaces of the shell 'C' will be :-



(A) $\frac{3}{4}$ (B) $-\frac{3}{4}$ (C) $\frac{3}{2}$ (D) $-\frac{3}{2}$

ES0120

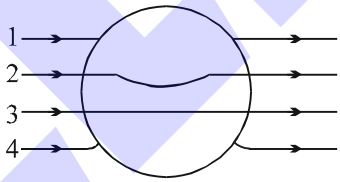
67. If the electric potential of the inner metal sphere is 10 volt & that of the outer shell is 5 volt, then the potential at the centre will be :



(A) 10 volt (B) 5 volt (C) 15 volt (D) 0

ES0121

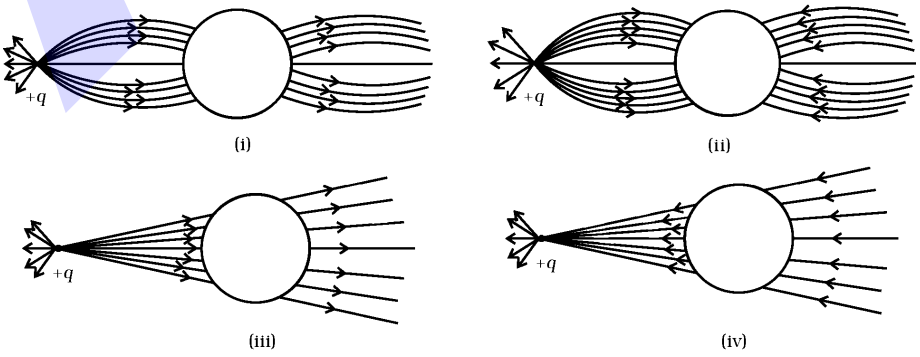
68. A metallic solid sphere is placed in a uniform electric field. The lines of force follow the path (s) shown in figure as :



(A) 1 (B) 2 (C) 3 (D) 4

ES0123

69. A point positive charge is brought near an isolated conducting sphere. The electric field is best given by



(A) Fig (i) (B) Fig (iii) (C) Fig (ii) (D) Fig (iv)

ES0124

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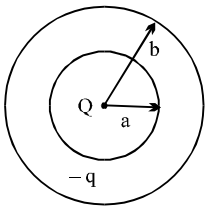
70. Both question (a) and (b) refer to the system of charges as shown in the figure. A spherical shell with an inner radius 'a' and an outer radius 'b' is made of conducting material. A point charge +Q is placed at the centre of the spherical shell and a total charge – q is placed on the shell.

a. Charge – q is distributed on the surfaces as



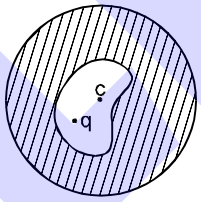
(A) – Q on the inner surface, – q on outer surface
(B) – Q on the inner surface, – q + Q on the outer surface
(C) +Q on the inner surface, –q – Q on the outer surface
(D) The charge –q is spread uniformly between the inner and outer surface.

b. Assume that the electrostatic potential is zero at an infinite distance from the spherical shell. The electrostatic potential at a distance R (a < R < b) from the centre of the shell is (where $K = \frac{1}{4\pi\varepsilon_0}$)

(A) 0 (B) $\frac{KQ}{a}$ (C) $K\frac{Q-q}{R}$ (D) $K\frac{Q-q}{b}$

ES0117

71. The figure shows a charge q placed inside a cavity in an uncharged conductor. Now if an external electric field is switched on :



(A) only induced charge on outer surface will redistribute.
(B) only induced charge on inner surface will redistribute.
(C) both induced charge on outer and inner surface will redistribute.
(D) force on charge q placed inside the cavity will change.

ES0339

72. Consider a conductor with a spherical cavity in it. A point charge q_0 is placed at the centre of cavity and a point charge Q is placed outside conductor.

Statement-1 : Total charge induced on cavity wall is equal and opposite to the charge inside.

Statement-2 : If cavity is surrounded by a Gaussian surface, where all parts of Gaussian surface are located inside the conductor, $\oint \vec{E}.d\vec{A} = 0$; hence $q_{induced} = -q_0$

(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
(C) Statement-1 is true, statement-2 is false.
(D) Statement-1 is false, statement-2 is true.

ES0132

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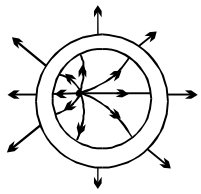
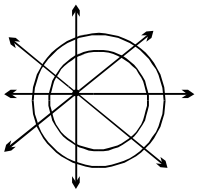
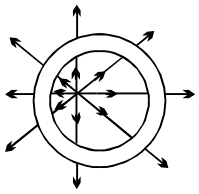
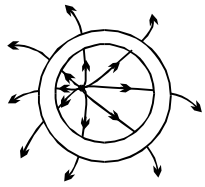
73. n small drops of same size are charged to V volts each. If they coalesce to form a signal large drop, then its potential will be :-

(A) V/n (B) Vn (C) $Vn^{1/3}$ (D) $Vn^{2/3}$

ES0122

74. A point charge *q* is placed at a point inside a hollow conducting sphere. Which of the following electric force pattern is correct ? **[IIT-JEE'2003 (scr)]**

(A)  (B)  (C)  (D) 

ES0130

75. The electric field at a distance R due to charge q is E. If the same charge is placed on the copper sphere of radius R, the electric field strength at the surface of the conductor will be

(A) $E/4$ (B) $E/2$ (C) E (D) 2 E

ES0340

76. The surface density on the copper sphere is σ. The electric field strength on the surface of the sphere is

(A) σ (B) $\sigma/2$ (C) σ/ε_0 (D) $\sigma/2\varepsilon_0$

ES0341

77. The dimension of $(1/2)\varepsilon_0 E^2$ (ε_0 : permittivity of free space; E: electric field) is

(A) $ML^{-1}T^{-2}$ (B) ML^2T^{-2} (C) MLT^{-2} (D) ML^2T^{-1}

ES0342

78. A spherical charged conductor has σ as the surface density of charge. The electric field on its surface is E. If the radius of the sphere is doubled keeping the surface density of charge unchanged, what will be the electric field on the surface of the new sphere ?

(A) E/4 (B) E/2 (C) E (D) 2E

ES0343

79. In the above question, if the electric potential of the conductor in the first case be V, then what will be the electric potential in the second case ?

(A) V/4 (B) V/2 (C) V (D) 2 V

ES0344

80. Two isolated spherical shell having charges Q_1 and Q_2 and radii r_1 and r_2 are kept at very large separation. If they are joined by a conducting wire, then choose **incorrect** statement:

(A) Electrostatic potential energy of system must decrease.

(B) Electrostatic potential energy of system may decrease.

(C) If $Q_1 r_2 = Q_2 r_1$, then no charge flow through the conducting wire.

(D) If $Q_1 r_2 = Q_2 r_1$, then electrostatic potential energy of system already minimum.

ES0345

81. A sphere of radius $1\,cm$ has potential of $8000\,V$, then energy density near its surface will be

(A) $64\times10^5\,J/m^3$ (B) $8\times10^3\,J/m^3$ (C) $32\,J/m^3$ (D) $2.83\,J/m^3$

ES0346

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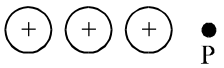
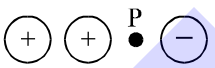
EXERCISE (O-2)

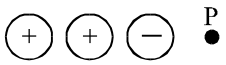
SINGLE CORRECT TYPE QUESTIONS

A. Coulomb's Law

1. Given are four arrangements of three fixed electric charges. In each arrangement, a point labeled P is also identified — test charge, +q, is placed at point P. All of the charges are of the same magnitude, Q, but they can be either positive or negative as indicated. The charges and point P all lie on a straight line. The distances between adjacent items, either between two charges or between a charge and point P, are all the same. Correct order of choices in a decreasing order of magnitude of force on P is

I. 

II. 

III. 

IV.

(A) II > I > III > IV (B) I > II > III > IV (C) II > I > IV > III (D) III > IV > I > II

ES0059

2. Two point charge of 100 μC and –4 μC are positioned at points $(-2\sqrt{3}, 3\sqrt{3}, -4)$ and $(4\sqrt{3}, -5\sqrt{3}, 6)$ respectively of a Cartesian coordinate system. Find the force vector on the –4 μC charge? All the coordinates are in meters.

(A) $9\times10^{-4}\left(3\sqrt{3}\hat{i}-4\sqrt{3}\hat{j}+5\hat{k}\right)$ (B) $9\times10^{-4}\left(-3\sqrt{3}\hat{i}+4\sqrt{3}\hat{j}-5\hat{k}\right)$

(C) $2.25\times10^{-4}\left(-3\sqrt{3}\hat{i}+4\sqrt{3}\hat{j}-5\hat{k}\right)$ (D) $2.25\times10^{-4}\left(3\sqrt{3}\hat{i}-4\sqrt{3}\hat{j}+5\hat{k}\right)$

ES0060

3. A charge q is placed at the centroid of an equilateral triangle. Three equal charges Q are placed at the vertices of the triangle. The system of four charges will be in equilibrium if q is equal to :-

(A) $\frac{-Q}{\sqrt{3}}$ (B) $\frac{-Q}{3}$ (C) $-Q\sqrt{3}$ (D) $\frac{Q}{\sqrt{3}}$

ES0066

4. Two identical charged spheres suspended from a common point by two massless string of length ℓ are initially a distance d($d << \ell$) apart because of their mutual repulsion. The charge begins to leak from both the spheres at a constant rate. As a result the charges approach each other with a velocity v. Then as a function of distance x between them :- **[AIEEE - 2011]**

(A) $v \propto x^{1/2}$ (B) $v \propto x$ (C) $v \propto x^{-1/2}$ (D) $v \propto x^{-1}$

ES0192

B. Electric Field

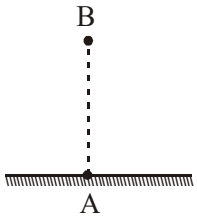
5. There are two point charges q_1 and q_2 lying on a circle of unit radius. Electric field intensity at the center of circle due to these charges is $\vec{E}$. Find the position vector of the center with respect to q_2 if the position vector of the center with respect to q_1 is $\vec{r}_1$.

(A) $\frac{\vec{E}+kq_1\vec{r}_1}{kq_2}$ (B) $-\left(\frac{\vec{E}+kq_1\vec{r}_1}{kq_2}\right)$ (C) $\frac{kq_1\vec{r}_1-\vec{E}}{kq_2}$ (D) $\frac{\vec{E}-kq_1\vec{r}_1}{kq_2}$

ES0062

node06\B0BC-BD\Kota\JEE(Advanced)\Enthuse\Phy\Module\2-Electro-Grav-Current Elec.-Copy\Eng\01_Electrostatics\01_Eng.p65

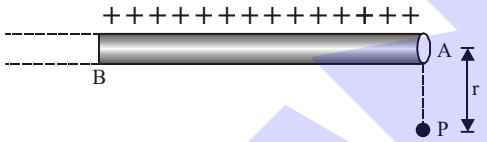
6. Particle *B* of charge *Q* and mass m is in equilibrium under weight and electrostatics force applied by a fixed charged *A*, which is directly beneath the particle *B* as shown in figure. When particle B is disturbed along vertical, the equilibrium is



(A) stable
(B) unstable
(C) neutral
(D) there can not be in equilibrium

ES0065

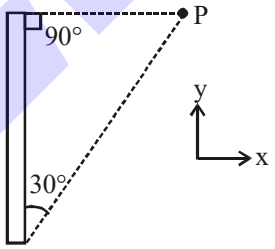
7. A semi-infinite insulating rod has linear charge density λ. The electric field at the point P shown in figure is :-



(A) $\frac{2\lambda^2}{(4\pi\varepsilon_0 r)^2}$ at 45° with AB
(B) $\frac{\sqrt{2}\lambda}{4\pi\varepsilon_0 r^2}$ at 45° with AB
(C) $\frac{\sqrt{2}\lambda}{4\pi\varepsilon_0 r}$ at 45° with AB
(D) $\frac{\sqrt{2}\lambda}{4\pi\varepsilon_0 r}$ at perpendicular to AB

ES0067

8. The direction (θ) of $\vec{E}$ at point P due to uniformly charged finite rod will be :-



(A) at angle 30° from x-axis
(B) 45° from x-axis
(C) 60° from x-axis
(D) none of these

ES0068

9. A particle of mass m, charge –Q is constrained to move along the axis of a ring of radius a. The ring carries a uniform charge density + λ along its circumference. Initially, the particle lies in the plane of the ring at a point where no net force acts on it. The period of oscillation of the particle when it is displaced slightly from its equilibrium position is

(A) $T = 4\pi\sqrt{\frac{\varepsilon_0 ma^2}{\lambda Q}}$ (B) $T = 2\pi\sqrt{\frac{2\varepsilon_0 ma^2}{\lambda Q}}$ (C) $T = 2\pi\sqrt{\frac{4\varepsilon_0 ma^2}{\lambda Q}}$ (D) $T = 2\pi\sqrt{\frac{\varepsilon_0 ma^2}{2\lambda Q}}$

ES0072

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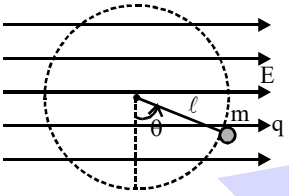
10. The surface charge density of a thin charged disc of radius R is σ. The value of the electric field at the centre of the disc is $\frac{\sigma}{2\epsilon_0}$. With respect to the field at the centre, the electric field along the axis at a distance $\sqrt{3}$ R from the centre of the disc :

(A) reduces by 70.7% (B) reduces by 29.3% (C) reduces by 86.6% (D) reduces by 13.4%

ES0073

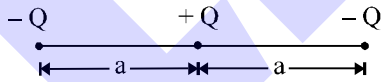
11. A small ball of mass m and charge +q tied with a string of length ℓ, is rotating in a vertical circle under gravity and a uniform horizontal electric field E as shown. The tension in the string will be minimum for:-

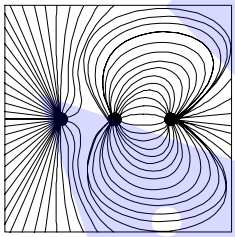
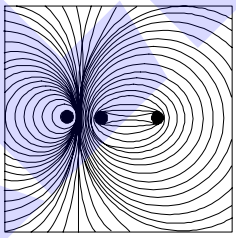
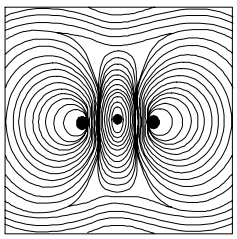
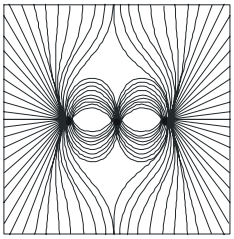


(A) $\theta = \tan^{-1}\left(\frac{qE}{mg}\right)$ (B) $\theta = \pi$ (C) $\theta = \pi - \tan^{-1}\left(\frac{qE}{mg}\right)$ (D) $\theta = \pi + \tan^{-1}\left(\frac{qE}{mg}\right)$

ES0074

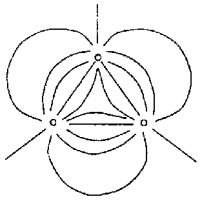
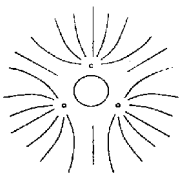
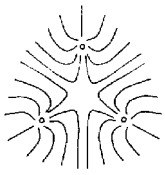
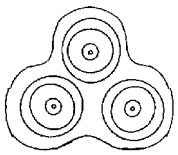
12. The fig. shows the distribution of three charges –Q, +Q and –Q on the X-axis. Which of the following figures shows the possible electric field lines for the distribution?



(A)  (B)  (C)  (D) 

ES0078

13. Three positive charges of equal value q are placed at the vertices of an equilateral triangle. The resulting lines of force should be sketched as in **[JEE 2001 (Scr)]**

(A)  (B)  (C)  (D) 

ES0102

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14. Consider the following conclusions regarding the components of an electric field at a certain point in space given by

$E_x = -Ky$ $E_y = Kx$ $E_z = 0$

(I) The field is conservative. (II) The field is non-conservative.

(III) The lines of force are staright lines (IV) The lines of force are circles.

Of these conclusions

(A) II and IV are valid (B) I and III are valid

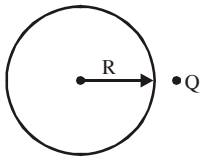
(C) I and IV are valid (D) II and III are valid

ES0108

C. Electric Flux

15. **Statement 1:** A charge is outside the Gaussian sphere of radius R. Then electric field on the surface of sphere is zero.

and



Statement 2 : As $\oint \vec{E} \cdot d\vec{s} = \frac{q_{in}}{\varepsilon_0}$, for the sphere q_{in} is zero, so $\oint \vec{E} \cdot d\vec{s} = 0$.

(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

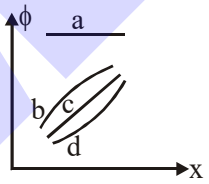
(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(C) Statement-1 is true, statement-2 is false.

(D) Statement-1 is false, statement-2 is true.

ES0081

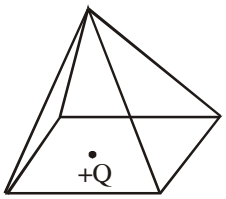
16. A line of charge extends along a X-axis whose linear charge density varies directly as x. Imagine a spherical volume with its centre located on X-axis and is moving gradually along it. Which of the graphs shown in figure correspond to the flux ϕ with the x coordinate of the centre of the volume?



(A) a (B) b (C) c (D) d

ES0085

17. A point charge +Q is positioned at the center of the base of a square pyramid as shown. The flux through one of the four identical upper faces of the pyramid is :-

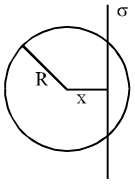


(A) $\frac{Q}{16\varepsilon_0}$ (B) $\frac{Q}{4\varepsilon_0}$ (C) $\frac{Q}{8\varepsilon_0}$ (D) None of these

ES0087

node06\B0BC-BD\Kota\JEE(Advanced)\Enthuse\Phy\Module\2.Electro-Grav+Current Elec.-Capa\Eng\01_Electrostatics\01_Eng.p65

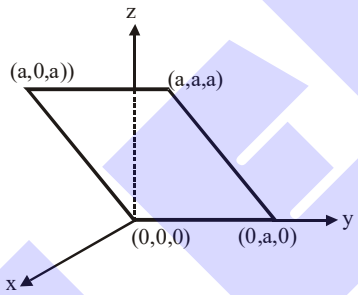
18. An infinite, uniformly charged sheet with surface charge density σ cuts through a spherical Gaussian surface of radius R at a distance x from its center, as shown in the figure. The electric flux Φ through the Gaussian surface is :-



(A) $\frac{\pi R^2\sigma}{\varepsilon_0}$ (B) $\frac{2\pi\left(R^2-x^2\right)\sigma}{\varepsilon_0}$ (C) $\frac{\pi(R-x)^2\sigma}{\varepsilon_0}$ (D) $\frac{\pi\left(R^2-x^2\right)\sigma}{\varepsilon_0}$

ES0088

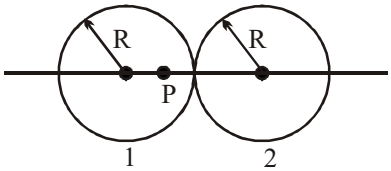
19. Consider an electric field $\vec{E}=E_0\hat{x}$, where E_0 is a constant. The flux through the shaded area (as shown in the figure) due to this field is **[IIT-JEE 2011]**



(A) $2E_0a^2$ (B) $\sqrt{2}E_0a^2$ (C) E_0a^2 (D) $\frac{E_0a^2}{\sqrt{2}}$

ES0206

20. Figure shows, in cross section, two solid spheres with uniformly distributed charge throughout their volumes. Each has radius R. Point P lies on a line connecting the centres of the spheres, at radial distance R/2 from the center of sphere 1. If the net electric field at point P is zero and Q_1 is 64 μC, what is Q_2(in μC).



(A) 64 (B) 36 (C) 32 (D) 72

ES0082

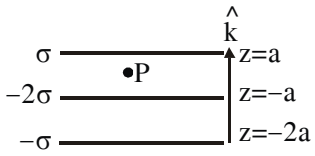
21. A sphere of radius R carries charge density proportional to the square of the distance from the center: $\rho = Ar^2$, where A is a positive constant. At a distance of R/2 from the center, the magnitude of the electric field is :-

(A) $A/4\pi\varepsilon_0$ (B) $AR^3/40\varepsilon_0$ (C) $AR^3/24\varepsilon_0$ (D) $AR^3/5\varepsilon_0$

ES0083

node06\B0BC-BD\Kota\JEE(Advanced)\Enthuse\Phy\Module\2-Electro-Gravi-Current Elec.-Copy\Eng\01_Electrostatics\01_Eng.p65

22. Three large parallel plates have uniform surface charge densities as shown in the figure. What is the electric field at *P*? **[IIT-JEE 2005 (Scr)]**



(A) $-\frac{4\sigma}{\epsilon_0}\hat{k}$ (B) $\frac{4\sigma}{\epsilon_0}\hat{k}$ (C) $-\frac{2\sigma}{\epsilon_0}\hat{k}$ (D) $\frac{2\sigma}{\epsilon_0}\hat{k}$

ES0084

23. For a spherically symmetrical charge distribution, electric field at a distance r from the centre of sphere is $\vec{E} = kr^7\hat{r}$, where k is a constant. What will be the volume charge density at a distance r from the centre of sphere?

(A) $\rho = 3k\varepsilon_0 r^6$ (B) $\rho = 5k\varepsilon_0 r^3$ (C) $\rho = 3k\varepsilon_0 r^4$ (D) $\rho = 9k\varepsilon_0 r^6$

ES0347

D. Electric Potential Energy

24. Two particles X and Y, of equal mass and with unequal positive charges, are free to move and are initially far away from each other. With Y at rest, X begins to move towards it with initial velocity u. After a long time, finally :-

(A) X will stop, Y will move with velocity u.
(B) X and Y will both move with velocities u/2 each.
(C) X will stop, Y will move with velocity < u.
(D) both will move with velocities < u/2.

ES0090

25. Two fixed charges A and B of 5 μC each are separated by a distance of 6m. C is the mid point of the line joining A and B. A charge 'Q' of –5μC is shot perpendicular to the line joining A and B through C with a kinetic energy of 0.06J. The charge 'Q' comes to rest at a point D. The distance CD is:-

(A) 3 m (B) $\sqrt{3}$ m (C) $3\sqrt{3}$ m (D) 4 m

ES0094

26. A positively charged particle is released from rest in an uniform electric field. The electric potential energy of the charge

(A) remains a constant because the electric field is uniform.
(B) increases because the charge moves along the electric field.
(C) decreases because the charge moves along the electric field.
(D) decreases because the charge moves opposite to the electric field.

ES0099

27. Two positive charges of magnitude 'q' are placed at the ends of a side (side 1) of a square of side '2a'. Two negative charges of the same magnitude are kept at the other corners. Starting from rest, if a charge Q moves from the middle of side 1 to the centre of square, its kinetic energy at the centre of square is :- **[AIEEE - 2011]**

(A) $\frac{1}{4\pi\epsilon_0}\frac{2qQ}{a}\left(1-\frac{1}{\sqrt{5}}\right)$ (B) zero

(C) $\frac{1}{4\pi\epsilon_0}\frac{2qQ}{a}\left(1+\frac{1}{\sqrt{5}}\right)$ (D) $\frac{1}{4\pi\epsilon_0}\frac{2qQ}{a}\left(1-\frac{2}{\sqrt{5}}\right)$

ES0194

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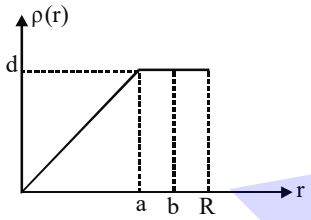
E. Electric Potential

28. When a negative charge is released and moves in electric field, it moves toward a position of
(A) lower electric potential and lower potential energy
(B) lower electric potential and higher potential energy
(C) higher electric potential and lower potential energy
(D) higher electric potential and higher potential energy

ES0098

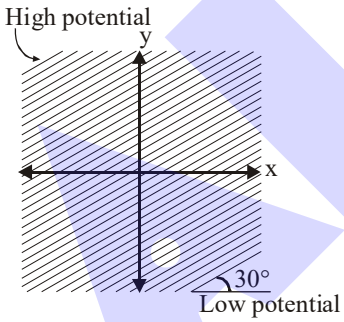
29. The nuclear charge (Ze) is non-uniformly distribute within a nucleus of radius R. The charge density ρ(r) [charge per unit volume] is dependent on the radial distance r from the centre of the nucleus as shown in figure. Select correct alternative/s.

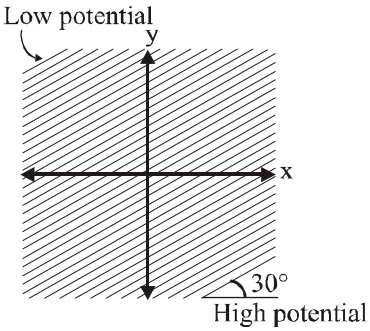


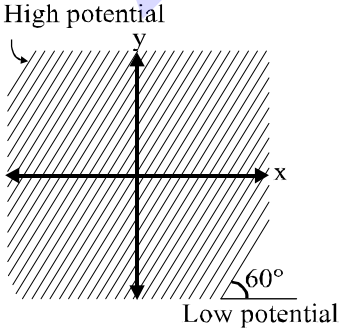
(A) Electric field at r = R is independent of b
(B) Electric potential at r = R is proportional to b
(C) Electric field at r = R is proportional to a
(D) Electric potential at r = R is proportional to a

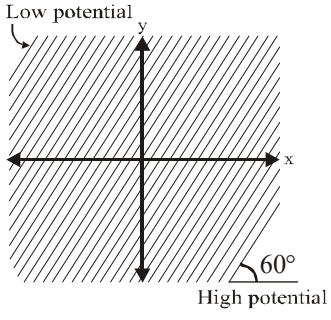
ES0096

30. The electric field intensity at all points in space is given by $\vec{E} = \sqrt{3}\hat{i} - \hat{j}$ volts/metre. The nature of equipotential lines in x-y plane is given by :-

(A)


(B)


(C)


(D)


ES0100

node06\B0BC-BD\Kota\JEE(Advanced)\Enthuse\Phy\Module\2.Electro-Gravi-Current Elec.-Copy\Eng\01_Electrostatics\01_Eng.p65

31. In an electric field the potential at a point is given by the following relation $V = \frac{343}{r}$. The electric field at $\vec{r} = 3\hat{i} + 2\hat{j} + 6\hat{k}$ is :

(A) $21\hat{i} + 14\hat{j} + 42\hat{k}$ (B) $3\hat{i} + 2\hat{j} + 6\hat{k}$ (C) $\frac{1}{7}\left(3\hat{i} + 2\hat{j} + 6\hat{k}\right)$ (D) $-\left(3\hat{i} + 2\hat{j} + 6\hat{k}\right)$

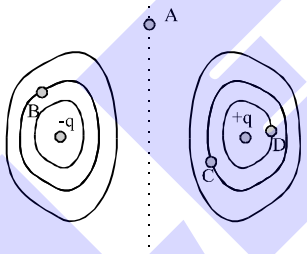
ES0103

32. From a point if we move in a direction making an angle θ measured from +ve x-axis , the potential gradient is given as $\frac{dv}{dr} = 2\cos\theta$. Find the direction and magnitude of electric field at that point.

(A) $2\hat{i}$ (B) $-2\hat{i}$ (C) $\hat{i} + \hat{j}$ (D) $-\hat{i} + \hat{j}$

ES0104

33. Figure shows equi-potential surfaces for a two charges system. At which of the labeled points point will an electron have the highest potential energy?



(A) Point A (B) Point B (C) Point C (D) Point D

ES0106

34. The electrostatic potential inside a charged spherical ball is given by $\phi = ar^2 + b$ where r is the distance from the centre; a, b are constant. Then the charge density inside the ball is :- **[AIEEE - 2011]**

(A) $-24\pi\, a\in_0$ (B) $-6\, a\in_0$ (C) $-24\pi\, a\in_0 r$ (D) $-6\, a\in_0 r$

ES0193

F. Dipole

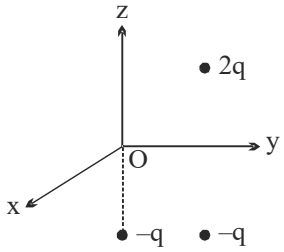
35. Three point charges 2q, –q and –q are located respectively at (0, a, a), (0, a, –a) and (0, 0, – a) as shown. The dipole moment of this distribution is :-

(A) 2qa in the y–z plane at $\tan^{-1}\left(\frac{1}{4}\right)$ with z-axis

(B) $\sqrt{17}$qa in the y–z plane at $\tan^{-1}\left(\frac{1}{4}\right)$ with z-axis

(C) $\sqrt{5}$qa in the x–y plane at $\tan^{-1}(4)$ with y-axis

(D) 4qa in the x–y plane at $\tan^{-1}(4)$ with y-axis



ES0111

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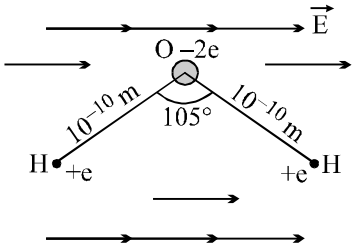
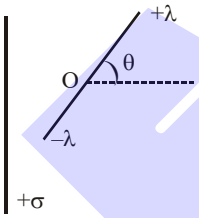
36. A water molecule as shown is in a region of uniform electric field $\vec{E} = 1000\,\hat{i}$ V/m. This molecule experiences



(A) A counterclockwise torque
(B) A clockwise torque
(C) A net force to the right
(D) A net force to the left

ES0113

37. A large sheet carries uniform surface charge density σ. A rod of length 2ℓ has a linear charge density λ on one half and – λ on the other half. The rod is hinged at mid point O and makes angle θ with the normal to the sheet. The torque experienced by the rod is :-



(A) $\frac{\sigma\lambda\ell^2}{2\varepsilon_0}\cos\theta$
(B) $\frac{\sigma\lambda\ell}{\varepsilon_0}\cos^2\theta$
(C) $\frac{\sigma\lambda\ell^2\sin\theta}{2\varepsilon_0}$
(D) $\frac{\sigma\lambda\ell\sin^2\theta}{\varepsilon_0}$

ES0115

G. Conductors

38. The electrostatic potential on the surface of a charged conducting sphere is 100V. Two statements are made in this regard:
S_1 : At any point inside the sphere, electric intensity is zero.
S_2 : At any point inside the sphere, the electrostatic potential is 100V.
Which of the following is a correct statement?
(A) S_1 is true but S_2 is false.
(B) Both S_1 & S_2 are false.
(C) S_1 is true, S_2 is also true and S_1 is the cause of S_2.
(D) S_1 is true, S_2 is also true but the statements are independent.

ES0118

39. There are two uncharged identical metallic spheres 1 and 2 of radius r separated by a distance d (d >> r). A charged metallic sphere of same radius having charge q is touched with one of the sphere. After some time it is moved away from the system. Now the uncharged sphere is earthed. Charge on earthed sphere is
(A) q
(B) – q
(C) – qr/2d
(D) 0

ES0125

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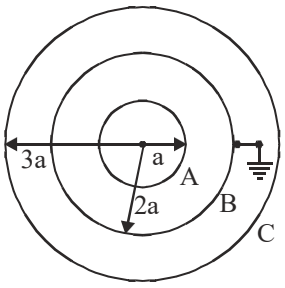
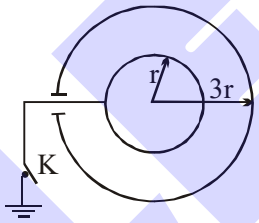
40. Figure shows a system of three concentric metal shells A, B and C with radii a, 2a and 3a respectively. Shell B is earthed and shell C is given a charge Q. Now if shell C is connected to shell A, then the final charge on the shell B, is equal to :



(A) $-\frac{4Q}{13}$ (B) $-\frac{8Q}{11}$ (C) $-\frac{5Q}{3}$ (D) $-\frac{3Q}{7}$

ES0127

41. Figure shows two conducting thin concentric shells of radii r and 3r. The outer shell carries charge q and inner shell is neutral. The amount of charge which flows from inner shell to the earth after the key K is closed, is equal to :-

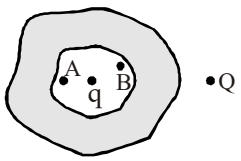


(A) –q/3 (B) q/3 (C) 3q (D) –3q

ES0128

42. **Statement-1 :** A point charge q is placed inside a cavity of conductor as shown. Another point charge Q is placed outside the conductor as shown. Now as the point charge Q is pushed away from conductor, the potential difference $(V_A - V_B)$ between two points A and B within the cavity of sphere remains constant.

Statement-2 : The electric field due to charges on outer surface of conductor and outside the conductor is zero at all points inside the conductor.



(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(C) Statement-1 is true, statement-2 is false.

(D) Statement-1 is false, statement-2 is true.

ES0129

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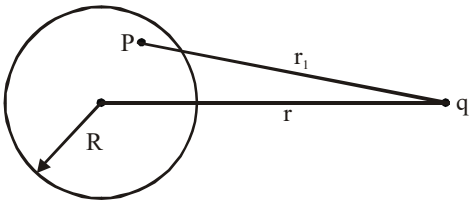
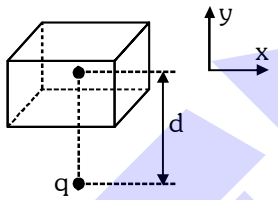
43. A point charge q is placed at a distance r from center of a conducting neutral sphere of radius R (r>R). The potential at any point P inside the sphere at a distance r_1 from point charge due to induced charge of the sphere is given by :-



(A) $\frac{Kq}{r_1}-\frac{Kq}{R}$ (B) $\frac{Kq}{r_1}-\frac{Kq}{R}$ (C) $\frac{Kq}{r}-\frac{Kq}{r_1}$ (D) $-\frac{Kq}{r_1}+\frac{Kq}{R}$

ES0131

44. A charge +q is placed at a distance 'd' from the centre of the uncharged metallic cube of side 'a'. The electric field at the centre of the cube due to induced charges on the cube will be



(A) zero (B) $\frac{q}{4\pi\in_0 d^2}\left(-\hat{j}\right)$ (C) $\frac{q}{4\pi\in_0 d^2}\left(\hat{j}\right)$ (D) $\frac{q}{4\pi\in_0\left(d-\frac{a}{2}\right)^2}\left(-\hat{j}\right)$

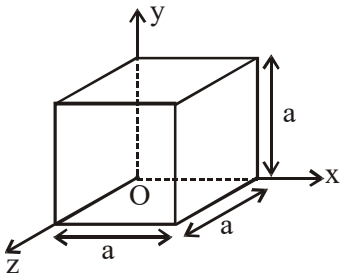
ES0348

45. Two non-conducting hemispherical surfaces, which are having uniform charge density σ are placed on smooth horizontal surface as shown in figure. Assuming springs are ideal, calculate compression in each spring if both the hemispherical surface are just touching each other.

(A) $\frac{\sigma^2R^2}{2\varepsilon_0 k}$ (B) R (C) $\frac{\sigma^2\pi R^2}{2\varepsilon_0 k}$ (D) None of these

ES0133

46. Electric field in a region is found to be $E=3y\hat{j}$. The total energy stored in electric field inside the cube shown will be



(A) $9a^5\in_0$ (B) $3\in_0 a^5$ (C) $\frac{3}{2}\in_0 a^5$ (D) 0 **ES0134**

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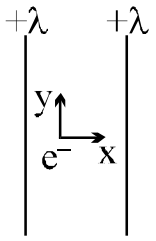
MULTIPLE CORRECT TYPE QUESTIONS

B. Electric Field

47. An electron is placed just in the middle between two long fixed line charges of charge density +λ each. The wires are in the xy plane (Do not consider gravity)



(A) The equilibrium of the electron will be unstable along x-direction

(B) The equilibrium of the electron will be neutral along y-direction

(C) The equilibrium of the electron will be stable along z-direction

(D) The equilibrium of the electron will be stable along y-direction

ES0136

48. Which statement(s) concerning electrostatic fields is/are **CORRECT**?

(A) Electric field lines never cross each other.

(B) Positive charge experiences force in the direction of electric field line.

(C) Electric field lines always start on negative charges and end on positive charges.

(D) Electric field lines that are closer indicate a stronger electric field while electric field lines that are far apart indicate a weaker electric field.

ES0137

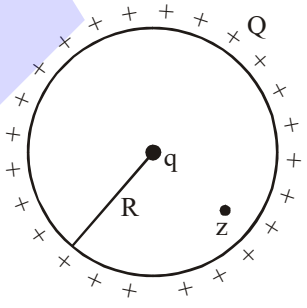
49. Which of the following represent(s) an electrostatic field :-

(A) $\vec{E} = y\hat{i} + x\hat{j}$ (B) $\vec{E} = y\hat{i}$

(C) $\vec{E} = y\hat{i} + x\hat{j} + z\hat{k}$ (D) $\vec{E} = \alpha\vec{r}$ (α is constant)

ES0141

50. A positive charge Q is uniformly distributed along a circular ring of radius *R*. A small test charge *q* is placed at the centre of the ring. Then



(A) If $q > 0$ and is displaced away from the centre in the plane of the ring, it will be pushed back towards the centre.

(B) If $q < 0$ and is displaced away from the centre in the plane of the ring, it will never return to the centre and will continue moving till it hits the ring.

(C) If $q < 0$, it will perform SHM for small displacement along the axis.

(D) *q* at the centre of the ring is in an unstable equilibrium within the plane of the ring for $q > 0$.

ES0143

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C. Electric Flux

51. If there were only one type of charge in the universe, then

(A) $\oint_s E.dS \neq 0$ on any surface.

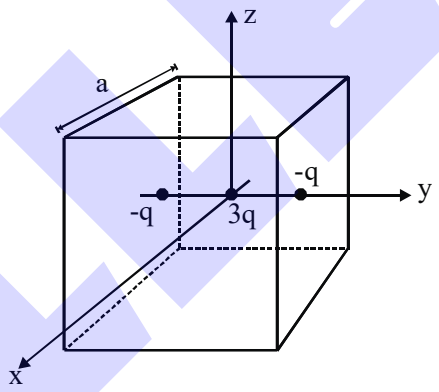
(B) $\oint_s E.dS = 0$ if the charge is outside the surface.

(C) $\oint_s E.dS$ could not be defined.

(D) $\oint_s E.dS = \frac{q}{\varepsilon_0}$ if charges of magnitude q were inside the surface.

ES0144

52. A cubical region of side a has its centre at the origin. It encloses three fixed point charges, –q at (0, –a/4, 0), +3q at (0,0,0) and –q at (0, +a/4, 0). Choose the correct option(s). **[IIT-JEE 2012]**



(A) The net electric flux crossing the plane x = +a/2 is equal to the net electric flux crossing the plane x = – a/2

(B) The net electric flux crossing the plane y = +a/2 is more than the net electric flux crossing the plane y = –a/2.

(C) The net electric flux crossing the entire region is $\frac{q}{\varepsilon_0}$

(D) The net electric flux crossing the plane z = +a/2 is equal to the net electric flux crossing the plane x = +a/2.

ES0213

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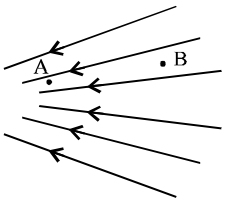
E. Electric Potential

53. Which of the following is true for the figure showing electric lines of force?
(E is electrical field, V is potential)



(A) $E_A > E_B$
(B) $E_B > E_A$
(C) $V_A > V_B$
(D) $V_B > V_A$

ES0146

54. Consider a uniform electric field in the $\hat{z}$ direction. The potential is a constant
(A) in all space.
(B) for any x for a given z.
(C) for any y for a given z.
(D) on the x-y plane for a given z.

ES0147

55. The electrostatic potential V at any point (x, y, z) in space is given by $V = 4x^2$. Then
(A) the y- and z-components of the electrostatic field at any point are zero
(B) the x-component of electric field at a point is given by $(-8x\,\hat{i})$
(C) the x-component of electric field at a point (1, 0, 2) is $(-8\,\hat{i})$
(D) the y- and z-components of the electric field are non-zero constant in magnitude.

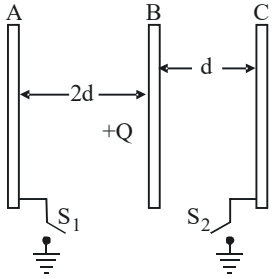
ES0349

56. Which of the following statement(s) is/are correct? **[IIT-JEE 2011]**
(A) If the electric field due to a point charge varies as $r^{-2.5}$ instead of r^{-2}, then the Gauss law will still be valid.
(B) The Gauss law can be used to calculate the field distribution around an electric dipole.
(C) If the electric field between two point charges is zero somewhere, then the sign of the two charges is the same.
(D) The work done by the external force in moving a unit positive charge from point A at potential V_A to point B at potential V_B is $(V_B - V_A)$

ES0209

G. Conductors

57. Three identical, parallel conducting plates A, B and C are placed as shown. Switches S_1 and S_2 are open, and can connect A and C to earth when closed. +Q charge is given to B.



(A) If S_1 is closed with S_2 open, a charge of amount Q will pass through S_1
(B) If S_2 is closed with S_1 open, a charge of amount Q will pass through S_2
(C) If S_1 and S_2 are closed together, a charge of amount Q/3 will pass through S_1, and a charge of amount 2Q/3 will pass through S_2.
(D) All the above statements are incorrect

ES0142

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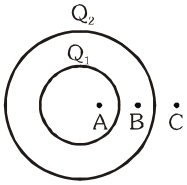
58. Figure shows two uniform charged concentric spherical shell. Both charges are positive, Select correct statement



(A) Electric field intensity at B may be greater than electric field intensity at C.

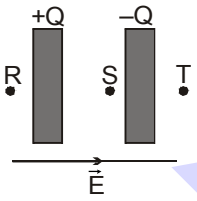
(B) Electric field intensity at B must be greater than electric field intensity at C.

(C) Potential at A greater than potential at B

(D) If a charge moves from B to C work done by electric force must be positive.

ES0145

59. Two large thin conducting plates with small gap in between are placed in a uniform electric field 'E' (perpendicular to the plates). Area of each plate is A and charges +Q and –Q are given to these plates as shown in the figure. If points R,S and T as shown in the figure are three points in space, then the



(A) field at point R is E

(B) field at point S is E

(C) field at point T is $\left(E+\frac{Q}{\epsilon_0 A}\right)$

(D) field at point S is $\left(E+\frac{Q}{A\epsilon_0}\right)$

ES0350

COMPREHENSION TYPE QUESTIONS

A. Coulomb's Law

Paragraph for Question Nos. 60 and 61

A dense collection of equal number of electrons and positive ions is called neutral plasma. Certain solids containing fixed positive ions surrounded by free electrons can be treated as neutral plasma. Let 'N' be the number density of free electrons, each of mass 'm'. When the electrons are subjected to an electric field, they are displaced relatively away from the heavy positive ions. If the electric field becomes zero, the electrons begins to oscillate about the positive ions with a natural angular frequency 'ω_p', which is called the plasma frequency. To sustain the oscillations, a time varying electric field needs to be applied that has an angular frequency ω, where a part of the energy is absorbed and a part of it is reflected. As ω approaches ω_p, all the free electrons are set to resonance together and all the energy is reflected. This is the explanation of high reflectivity of metals. **[IIT-JEE 2011]**

60. Taking the electronic charge as 'e' and the permittivity as 'ε_0', use dimensional analysis to determine the correct expression for ω_p.

(A) $\sqrt{\frac{Ne}{m\varepsilon_0}}$ (B) $\sqrt{\frac{m\varepsilon_0}{Ne}}$ (C) $\sqrt{\frac{Ne^2}{m\varepsilon_0}}$ (D) $\sqrt{\frac{m\varepsilon_0}{Ne^2}}$

ES0211

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61. Estimate the wavelength at which plasma reflection will occur for a metal having the density of electrons $N \approx 4 \times 10^{27} m^{-3}$. Take $\varepsilon_0 \approx 10^{-11}$ and $m \approx 10^{-30}$, where these quantities are in proper SI units

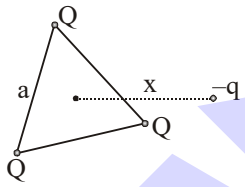
(A) 800 nm (B) 600 nm (C) 300 nm (D) 200 nm

ES0211

B. Electric Field

Paragraph for Questions No. 62 to 64

Three charged particles each of +Q are fixed at the corners of an equilateral triangle of side 'a'. A fourth particle of charge –q and mass m is placed at a point on the line passing through centroid of triangle and perpendicular to the plane of triangle at a distance x from the centre of triangle.



62. Magnitude of resultant force on the fourth charged particle is

(A) $\frac{1}{4\pi \in_0} \frac{9\sqrt{3}\, Qqx}{(3x^2 + a^2)^{3/2}}$ (B) $\frac{1}{4\pi \in_0} \frac{27\sqrt{3}\, Qqx}{(3x^2 + a^2)^{3/2}}$

(C) $\frac{1}{4\pi \in_0} \frac{2\sqrt{2}\, Qqx}{(2x^2 + a^2)^{3/2}}$ (D) $\frac{1}{4\pi \in_0} \frac{4\sqrt{2}\, Qqx}{(2x^2 + a^2)^{3/2}}$

ES0152

63. Value of x for which the force is maximum is

(A) $\frac{a}{\sqrt{3}}$ (B) $\frac{a}{\sqrt{2}}$ (C) $\frac{a}{\sqrt{6}}$ (D) $\frac{a}{\sqrt{5}}$

ES0152

64. For small oscillation the period of oscillation of fourth particle is

(A) $2\pi\sqrt{\frac{4\pi \in_0 ma^3}{9\sqrt{3}Qq}}$ (B) $\pi\sqrt{\frac{4\pi \in_0 ma^3}{9\sqrt{3}\, Qq}}$

(C) $2\pi\sqrt{\frac{2\pi \in_0 ma^3}{27\sqrt{3}\, Qq}}$ (D) $2\pi\sqrt{\frac{\pi \in_0 ma^3}{27\sqrt{3}\, Qq}}$

ES0152

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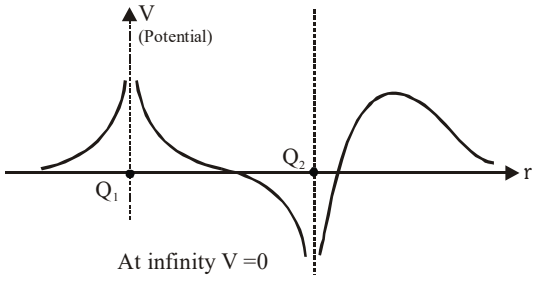
MATRIX MATCH TYPE QUESTION

E. Electric Potential

65. As shown in column I their are graphs of electric field (E) and potential (V) along the line joining charges Q_1 and Q_2 are drawn against distance (r) on x–axis for charges Q_1 and Q_2. Take potential at infinity equal to zero. [Take direction of E in righward direction as positive]

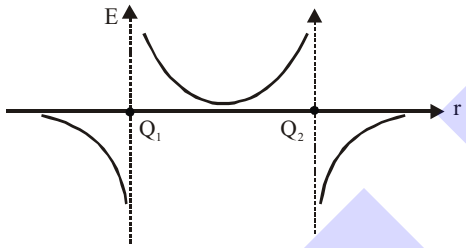
Column-I **Column-II**

(A)



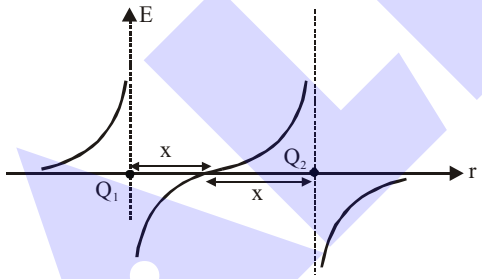
(P) $Q_1 < 0, Q_2 > 0$

(B)



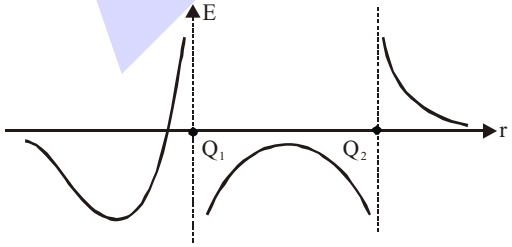
(Q) $Q_1 > 0, Q_2 < 0$

(C)



(R) $|Q_1| > |Q_2|$

(D)



(S) $Q_1 < 0, Q_2 < 0$

(T) $|Q_1| = |Q_2|$

ES0156

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G. Conductors

66. A spherical metallic conductor has a spherical cavity. A positive charge is placed inside the cavity at its centre. Another positive charge is placed outside it. The conductor is initially electrically neutral.

	Column-I (Cause)		**Column-II (Effect)**
(A)	If outside charge is shifted to other position	(P)	distribution of charge on inner surface of cavity changes
(B)	If inside charge is shifted to other position within cavity	(Q)	distribution of charge on outer surface of of conductor changes
(C)	If magnitude of charge inside cavity is increased	(R)	electric potential at centre of conductor due to charges present on outer surface of conductor changes
(D)	If conductor is earthed	(S)	force on the charge placed inside cavity changes

ES0158

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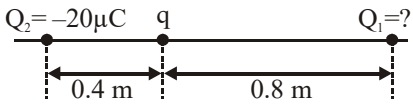
EXERCISE (S)

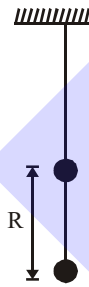
A. Coulomb's Law

1. Three charges are positioned in a straight line as depicted in the diagram. Using the information given in the diagram, determine the magnitude of charge 'Q_1' (in μC) if the charge q is to remain stationary.



ES0001

2. Two identical balls of mass m = 0.9 g each are charged by the same charges, joined by a thread and suspended from the ceiling (figure). Find the charge (in μC) that each ball should have so that the tension in both the threads are same? The distance between the centers of balls is R = 3m.



ES0002

3. Two charged balls are connected by an inextensible thread of length 3 m. Masses of balls are 2kg and 1 kg, the charges are +20 μC and –100 μC. What minimum constant external force F (in N) must be applied to the ball of mass 1 kg so that the thread does not slack? Neglect gravity and friction.

ES0005

B. Electric Field

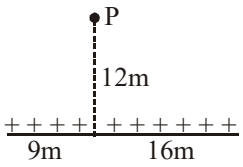
4. Two point charge –4Q and 9Q are placed at a distance 2m from each other. The position at which net electric field is zero from the charge –4Q is x (in m). What is the value of x.

ES0006

5. A clock face has negative charges $-q, -2q, -3q, \ldots\ldots, -12q$ fixed at the positions of the corresponding numerals on the dial. Assume that the clock hands do not disturb the net field due to point charges. At what time does the hour hand point in the same direction is electric field at the centre of the dial.

ES0008

6. Find the magnitude of electric field (in N/C) due to a line charge of $\lambda = \left(2\sqrt{2}\right)$ nC/m at a point P as shown.



ES0009

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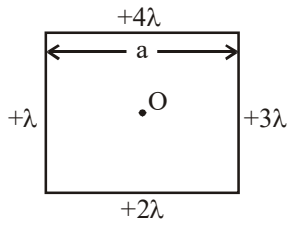
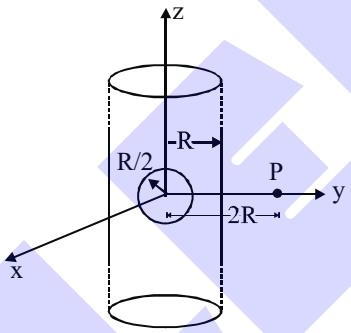
7. Four uniformly charged wires of length a are arranged to form a square. Linear charge density of each wire is as shown. Electric field intensity at centre of square is $\frac{nk\lambda}{a}$ then value of n



ES0010

8. An infinitely long solid cylinder of radius R has a uniform volume charge density ρ. It has a spherical cavity of radius R/2 with its centre on the axis of the cylinder, as shown in the figure. The magnitude of the electric field at the point P, which is at a distance 2R from the axis of the cylinder, is given by the expression $\frac{23\rho R}{16k\varepsilon_0}$. The value of k is **[IIT-JEE 2012]**



ES0212

C. Electric Flux

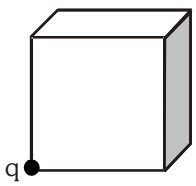
9. A non-uniform electric field in x-direction is increasing uniformly from 2N/C at x = 1m to 8 N/C at x = 7m. The center of cube is at x = 2m. If the charge enclosed inside a small cube of side length 10 cm is 8.85×10^{-5n} C. The value of n will be.

ES0016

10. A sphere of radius R has charge density given by $\rho = \rho_0\left(1-\frac{nr}{3R}\right)$, where ρ_0 is a constant, r is distance from centre of sphere. For a spherical gaussian surface of radius R centered at the centre of sphere, the flux is zero. Find 'n'.

ES0018

11. The length of each side of a cubical closed surface is ℓ. If charge q is situated on one of the vertices of the cube as shown then find the flux passing through shaded face of the cube.



ES0351

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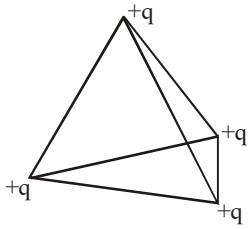
D. Electric Potential Energy

12. Four point charges are kept at the vertices of a regular tetrahedron of side R. Total electrostatic energy of the configuration is $\frac{\alpha kq^2}{R}$. The value of α is



ES0019

13. A particle of mass m carrying charge 'q' is projected with velocity (v) from point P towards an infinite line charge from a distance 'a'. Its speed reduces to zero momentarily at point Q which is at a distance a/2 from the line charge. If another particle with mass m and charge –q is projected with the same velocity v from point P towards the line charge. Its speed is found to be $\frac{Nv}{\sqrt{2}}$ at point 'Q'. Find the value of N.

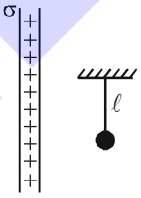
ES0025

14. You are given an arrangment of three point charges q, 2q and $\frac{-Xq}{3}$ separated by equal finite distances so that electric potential energy of the system is zero. Calculate the value of x.

ES0352

E. Electric Potential

15. A simple pendulum of length ℓ and bob mass m is hanging in front of a large nonconducting sheet of surface charge density σ. If suddenly a charge +q is given to the bob in the position shown in figure. Find the maximum angle through which the string is deflected from vertical.



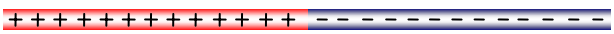
ES0026

16. A positive charge Q is uniformly distributed throughout the volume of a nonconducting sphere of radius R. A point mass having charge +q and mass m is fired towards the centre of the sphere with velocity v from a point at distance r(r > R) from the centre of the sphere. Find the minimum velocity v so that it can penetrate R/2 distance of the sphere. Neglect any resistance other than electric interaction. Charge on the small mass remains constant throughout the motion.

ES0028

F. Dipole

17. A plastic rod of length 1.0 m carries uniform positive charge +4.0 μC on half of its length and uniform negative charge –4.0 μ C on the remaining half of its length. Find magnitude of it's net dipole moment in μC–m.



ES0029

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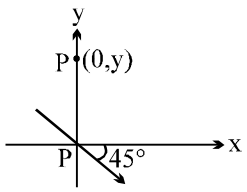
18. A dipole is placed at origin of coordinate system as shown in figure, find the electric field at point P (0, y).



ES0031

19. A dipole of dipole moment $\vec{p} = 2\hat{i} - 3\hat{j} + 4\hat{k}$ is placed at point A(2,–3,1). The electric potential due to this dipole at the point B(4,–1,0) is (ab) × 10^9 volt here 'a' represents sign (for negative answer select 0 for positive answer select 1. Write the value of $(a+b)^2$. The parameters specified here are in S.I. units.

ES0030

20. A charge +Q is fixed at the origin of the coordinate system while a small electric dipole of dipole-moment $\vec{p}$ pointing away from the charge along the x-axis is set free from a point far away from the origin.

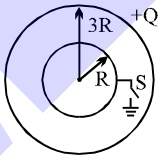
(a) calculate the K.E. of the dipole when it reaches to a point (d, 0) **[IIT-JEE 2003]**

(b) calculate the force on the charge +Q due to the dipole at this moment.

ES0033

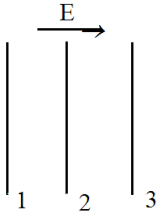
G. Conductors

21. Two thin conducting shells of radii R and 3R are shown in figure. The outer shell carries a charge +Q and the inner shell is neutral. The inner shell is earthed with the help of switch S. Find the charge attained by the inner shell.



ES0035

22. Three uncharge conducing large plates are placed parallel to each other in a uniform electric field. Find the induced charge density on each surface of each plate.



ES0038

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EXERCISE-JM

1. Let $[\in_0]$ denote the dimensional formula of the permittivity of vacuum. If M = mass, L = Length, T = Time and A = electric current, then : **[JEE-Main-2013]**

(1) $[\in_0] = [M^{-1} L^{-3} T^2 A]$ (2) $[\in_0] = [M^{-1} L^{-3} T^4 A^2]$

(3) $[\in_0] = [M^{-1} L^2 T^{-1} A^{-2}]$ (4) $[\in_0] = [M^{-1} L^2 T^{-1} A]$

ES0197

2. Two charges, each equal to q, are kept at x = –a and x = a on the x-axis. A particle of mass m and charge $q_0 = \frac{q}{2}$ is placed at the origin. If charge q_0 is given a small displacement (y << a) along the y-axis, the net force acting on the particle is proportional to **[JEE-Main-2013]**

(1) y (2) –y (3) $\frac{1}{y}$ (4) $-\frac{1}{y}$

ES0198

3. A charge Q is uniformly distributed over a long rod AB of length L as shown in the figure. The electric potential at the point O lying at a distance L from the end A is :- **[JEE-Main-2013]**

(1) $\frac{Q}{8\pi \in_0 L}$ (2) $\frac{3Q}{4\pi \in_0 L}$ (3) $\frac{Q}{4\pi \in_0 L \ln 2}$ (4) $\frac{Q \ln 2}{4\pi \in_0 L}$

ES0199

4. Assume that an electric field $\vec{E} = 30x^2\hat{i}$ exists in space. Then the potential difference $V_A - V_O$, where V_O is the potential at the origin and V_A the potential at x = 2 m is :- **[JEE-Main-2014]**

(1) –80 J (2) 80 J (3) 120 J (4) –120 J

ES0200

5. A uniformally charged solid sphere of radius R has potential V_0 (measured with respect to ∞) on its surface. For this sphere the equipotential surfaces with potentials $\frac{3V_0}{2}, \frac{5V_0}{4}, \frac{3V_0}{4}$ and $\frac{V_0}{4}$ have radius R_1, R_2, R_3 and R_4 respectively. Then **[JEE-Main-2015]**

(1) $R_1 = 0$ and $R_2 < (R_4 - R_3)$ (2) $2R < R_4$

(3) $R_1 = 0$ and $R_2 > (R_4 - R_3)$ (4) $R_1 \neq 0$ and $(R_2 - R_1) > (R_4 - R_3)$

ES0201

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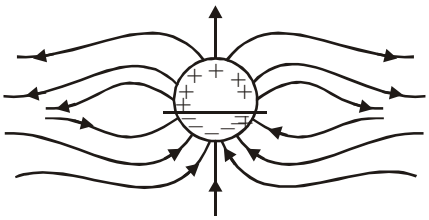
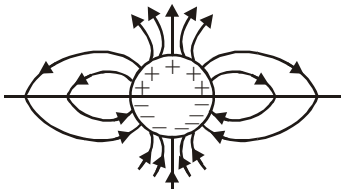
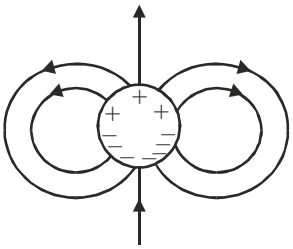
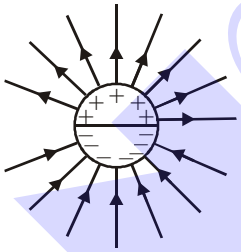
6. A long cylindrical shell carries positive surface charge σ in the upper half and negative surface charge $-\sigma$ in the lower half. The electric field lines around the cylinder will look like figure given in: (figures are schematic and not drawn to scale) **[JEE-Main-2015]**

(1) 

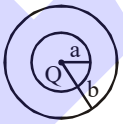
(2) 

(3) 

(4) 

ES0202

7. The region between two concentric spheres of radii 'a' and 'b', respectively (see figure), has volume charge density $\rho = \frac{A}{r}$, where A is a constant and r is the distance from the centre. At the centre of the spheres is a point charge Q. The value of A such that the electric field in the region between the spheres will be constant, is :- **[JEE-Main-2016]**



(1) $\frac{2Q}{\pi a^2}$ (2) $\frac{Q}{2\pi a^2}$ (3) $\frac{Q}{2\pi(b^2 - a^2)}$ (4) $\frac{2Q}{\pi(a^2 - b^2)}$

ES0203

8. An electric dipole has a fixed dipole moment $\vec{p}$, which makes angle θ with respect to x-axis. When subjected to an electric field $\vec{E}_1 = E\hat{i}$, it experiences a torque $\vec{T}_1 = \tau\hat{k}$. When subjected to another electric field $\vec{E}_2 = \sqrt{3}E_1\hat{j}$ it experiences torque $\vec{T}_2 = -\vec{T}_1$. The angle θ is : **[JEE-Main-2017]**

(1) 60° (2) 90° (3) 30° (4) 45°

ES0204

9. Three concentric metal shells A, B and C of respective radii a, b and c ($a < b < c$) have surface charge densities $+\sigma$, $-\sigma$ and $+\sigma$ respectively. The potential of shell B is :- **[JEE-Main-2018]**

(1) $\frac{\sigma}{\varepsilon_0}\left[\frac{a^2 - b^2}{b} + c\right]$ (2) $\frac{\sigma}{\varepsilon_0}\left[\frac{b^2 - c^2}{b} + a\right]$ (3) $\frac{\sigma}{\varepsilon_0}\left[\frac{b^2 - c^2}{c} + a\right]$ (4) $\frac{\sigma}{\varepsilon_0}\left[\frac{a^2 - b^2}{a} + c\right]$

ES0205

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SELECTED PROBLEMS FROM JEE-MAINS ONLINE PAPERS

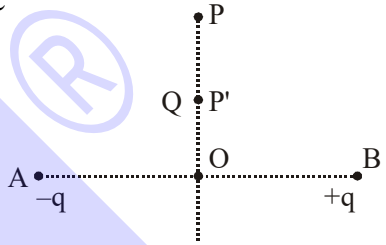
10. Charge is distributed within a sphere of radius R with a volume charge density $\rho(r)=\frac{A}{r^2}e^{-2r/a}$, where A and a are constants. If Q is the total charge of this charge distribution, the radius R is :

[JEE-Main-2019_Jan]

(1) $\frac{a}{2}\log\left(1-\frac{Q}{2\pi aA}\right)$ (2) $a\log\left(1-\frac{Q}{2\pi aA}\right)$ (3) $a\log\left(\frac{1}{1-\frac{Q}{2\pi aA}}\right)$ (4) $\frac{a}{2}\log\left(\frac{1}{1-\frac{Q}{2\pi aA}}\right)$

ES0247

11. Charges –q and +q located at A and B, respectively, constitute an electric dipole. Distance AB = 2a, O is the mid point of the dipole and OP is perpendicular to AB. A charge Q is placed at P where OP = y and y >> 2a. The charge Q experiences and electrostatic force F. If Q is now moved along the equatorial line to P' such that $OP'=\left(\frac{y}{3}\right)$, the force on Q will be close to : $\left(\frac{y}{3}>>2a\right)$ **[JEE-Main-2019_Jan]**



(1) $\frac{F}{3}$ (2) 3F (3) 9F (4) 27F

ES0248

12. Two electric dipoles, A, B with respective dipole moments $\vec{d}_A=-4qa\hat{i}$ and $\vec{d}_B=-2qa\hat{i}$ placed on the x-axis with a separation R, as shown in the figure

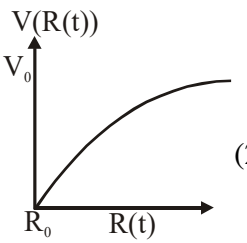
The distance from A at which both of them produce the same potential is : **[JEE-Main-2019_Jan]**

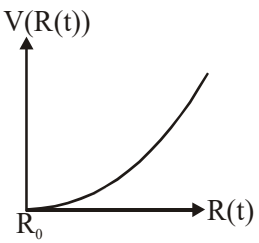
(1) $\frac{\sqrt{2}R}{\sqrt{2}+1}$ (2) $\frac{R}{\sqrt{2}+1}$ (3) $\frac{\sqrt{2}R}{\sqrt{2}-1}$ (4) $\frac{R}{\sqrt{2}-1}$

ES0249

13. There is a uniform spherically symmetric surface charge density at a distance R_0 from the origin. The charge distribution is initially at rest and starts expanding because of mutual repulsion. The figure that represents best the speed V(R(t)) of the distribution as a function of its instantaneous radius R (t) is:

[JEE-Main-2019_Jan]

(1)


(2)


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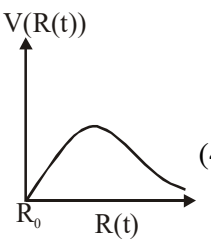

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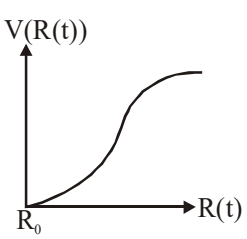

ES0250

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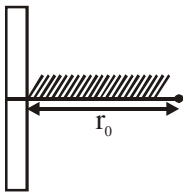
14. A positive point charge is released from rest at a distance r_0 from a positive line charge with uniform density. The speed (v) of the point charge, as a function of instantaneous distance r from line charge, is proportional to :- **[JEE-Main-2019_April]**



(1) $v \propto e^{+r/r_0}$ (2) $v \propto \ell n\left(\frac{r}{r_0}\right)$ (3) $v \propto \left(\frac{r}{r_0}\right)$ (4) $v \propto \sqrt{\ell n\left(\frac{r}{r_0}\right)}$

ES0251

15. A solid conducting sphere, having a charge Q, is surrounded by an uncharged conducting hollow spherical shell. Let the potential difference between the surface of the solid sphere and that of the outer surface of the hollow shell be V. If the shell is now given a charge of –4 Q, the new potential difference between the same two surfaces is : **[JEE-Main-2019_April]**

(1) V (2) 2V (3) –2V (4) 4V

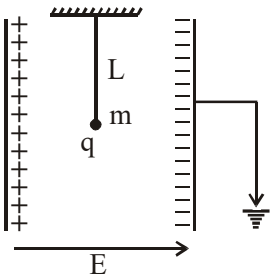
ES0252

16. Four point charges –q, +q, +q and –q are placed on y-axis at y = –2d, y = –d, y = +d and y = +2d, respectively. The magnitude of the electric field E at a point on the x-axis at x = D, with D >> d, will behave as :- **[JEE-Main-2019_April]**

(1) $E \propto \frac{1}{D}$ (2) $E \propto \frac{1}{D^3}$ (3) $E \propto \frac{1}{D^2}$ (4) $E \propto \frac{1}{D^4}$

ES0253

17. A simple pendulum of length L is placed between the plates of a parallel plate capacitor having electric field E, as shown in figure. Its bob has mass m and charge q. The time period of the pendulum is given by : **[JEE-Main-2019_April]**



(1) $2\pi\sqrt{\frac{L}{\sqrt{g^2+\left(\frac{qE}{m}\right)^2}}}$ (2) $2\pi\sqrt{\frac{L}{\left(g+\frac{qE}{m}\right)}}$ (3) $2\pi\sqrt{\frac{L}{\left(g-\frac{qE}{m}\right)}}$ (4) $2\pi\sqrt{\frac{L}{\sqrt{g^2-\frac{q^2E^2}{m^2}}}}$

ES0254

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18. A uniformly charged ring of radius 3a and total charge q is placed in xy-plane centred at origin. A point charge q is moving towards the ring along the z-axis and has speed u at z = 4a. The minimum value of u such that it crosses the origin is : **[JEE-Main-2019_April]**

(1) $\sqrt{\frac{2}{m}\left(\frac{1}{15}\frac{q^2}{4\pi\varepsilon_0 a}\right)^{1/2}}$ (2) $\sqrt{\frac{2}{m}\left(\frac{2}{15}\frac{q^2}{4\pi\varepsilon_0 a}\right)^{1/2}}$ (3) $\sqrt{\frac{2}{m}\left(\frac{4}{15}\frac{q^2}{4\pi\varepsilon_0 a}\right)^{1/2}}$ (4) $\sqrt{\frac{2}{m}\left(\frac{1}{5}\frac{q^2}{4\pi\varepsilon_0 a}\right)^{1/2}}$

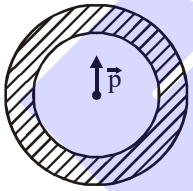
ES0255

19. Let a total charge 2Q be distributed in a sphere of radius R, with the charge density given by $\rho(r) = kr$, where r is the distance from the centre. Two charges A and B, of –Q each, are placed on diametrically opposite points, at equal distance, a, from the centre. If A and B do not experience any force, then : **[JEE-Main-2019_April]**

(1) $a = \frac{3R}{2^{1/4}}$ (2) $a = R/\sqrt{3}$ (3) $a = 8^{-1/4}R$ (4) $a = 2^{-1/4}\,R$

ES0256

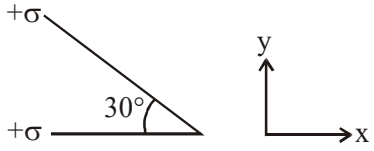
20. Shown in the figure is a shell made of a conductor. It has inner radius a and outer radius b, and carries charge Q. At its centre is a dipole $\vec{p}$ as shown. In this case : **[JEE-Main-2019_April]**



(1) Electric field outside the shell is the same as that of a point charge at the centre of the shell.
(2) Surface charge density on the inner surface of the shell is zero everywhere.
(3) Surface charge density on the inner surface is uniform and equal to $\frac{(Q/2)}{4\pi a^2}$.
(4) Surface charge density on the outer surface depends on $|\vec{p}|$

ES0257

21. Two infinite planes each with uniform surface charge density + σ are kept in such a way that the angle between them is 30°. The electric field in the region shown between them is given by: **[JEE-Main-2020_Jan]**



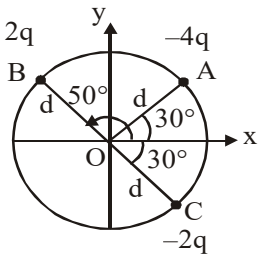
(1) $\frac{\sigma}{\varepsilon_0}\left[\left(1+\frac{\sqrt{3}}{2}\right)\hat{y}+\frac{\hat{x}}{2}\right]$ (2) $\frac{\sigma}{2\varepsilon_0}\left[\left(1-\frac{\sqrt{3}}{2}\right)\hat{y}-\frac{\hat{x}}{2}\right]$

(3) $\frac{\sigma}{2\varepsilon_0}\left[\left(1+\sqrt{3}\right)\hat{y}+\frac{\hat{x}}{2}\right]$ (4) $\frac{\sigma}{2\varepsilon_0}\left[\left(1+\sqrt{3}\right)\hat{y}-\frac{\hat{x}}{2}\right]$

ES0258

node06\B0BC-BD\Kota\JEE(Advanced)\Enthuse\Phy\Module\2-Electro-Gravi-Current Elec.-Copy\Eng\01_Electrostatics\01_Eng.p65

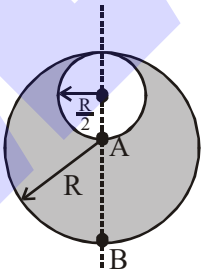
22. Three charged particle A, B and C with charges –4q, 2q and –2q are present on the circumference of a circle of radius d. the charged particles A, C and centre O of the circle formed an equilateral triangle as shown in figure. Electric field at O along x-direction is : **[JEE-Main-2020_Jan]**



(1) $\frac{2\sqrt{3}\,q}{\pi\varepsilon_0 d^2}$ (2) $\frac{\sqrt{3}\,q}{4\pi\varepsilon_0 d^2}$ (3) $\frac{3\sqrt{3}\,q}{4\pi\varepsilon_0 d^2}$ (4) $\frac{\sqrt{3}\,q}{\pi\varepsilon_0 d^2}$

ES0259

23. Consider a sphere of radius R which carries a uniform charge density ρ. If a sphere of radius $\frac{R}{2}$ is carved out of it, as shown, the ratio $\frac{|\vec{E}_A|}{|\vec{E}_B|}$ of magnitude of electric field $\vec{E}_A$ and $\vec{E}_B$, respectively, at points A and B due to the remaining portion is : **[JEE-Main-2020_Jan]**



(1) $\frac{18}{54}$ (2) $\frac{21}{34}$ (3) $\frac{17}{54}$ (4) $\frac{18}{34}$

ES0260

24. An electric dipole of moment $\vec{p} = (-\hat{i} - 3\hat{j} + 2\hat{k}) \times 10^{-29}$ C .m is at the origin (0, 0, 0). The electric field due to this dipole at $\vec{r} = +\hat{i} + 3\hat{j} + 5\hat{k}$ (note that $\vec{r}.\vec{p} = 0$) is parallel to: **[JEE-Main-2020_Jan]**

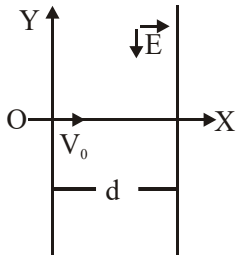
(1) $(-\hat{i} + 3\hat{j} - 2\hat{k})$ (2) $(+\hat{i} - 3\hat{j} - 2\hat{k})$

(3) $(+\hat{i} + 3\hat{j} - 2\hat{k})$ (4) $(-\hat{i} - 3\hat{j} + 2\hat{k})$

ES0261

node06\B0BC-BD\Kota\JEE(Advanced)\Enthuse\Phy\Module\2.Electro-Grav+Current Elec.-Capa\Eng\01_Electrostatics\01_Eng.p65

25. A charged particle (mass m and charge q) moves along X axis with velocity V_0. When it passes through the origin it enters a region having uniform electric field $\vec{E} = -E\hat{j}$ which extends upto x = d. Equation of path of electron in the region x > d is : **[JEE-Main-2020_Sep]**



(1) $y = \frac{qEd}{mV_0^2}\left(\frac{d}{2} - x\right)$ (2) $y = \frac{qEd}{mV_0^2}(x - d)$ (3) $y = \frac{qEd}{mV_0^2}x$ (4) $y = \frac{qEd^2}{mV_0^2}x$

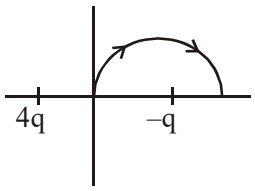
ES0262

26. Two isolated conducting spheres S_1 and S_2 of radius $\frac{2}{3}R$ and $\frac{1}{3}R$ have 12 μC and –3 μC charges, respectively, and are at a large distance from each other. They are now connected by a conducting wire. A long time after this is done the charges on S_1 and S_2 are respectively : **[JEE-Main-2020_Sep]**

(1) 6 μC and 3 μC (2) +4.5 μC and –4.5 μC
(3) 3 μC and 6 μC (4) 4.5 μC on both

ES0263

27. A two point charges 4q and –q are fixed on the x-axis at $x = -\frac{d}{2}$ and $x = \frac{d}{2}$, respectively. If a third point charge 'q' is taken from the origin to x = d along the semicircle as shown in the figure, the energy of the charge will : **[JEE-Main-2020_Sep]**



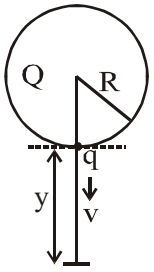
(1) increase by $\frac{2q^2}{3\pi\varepsilon_0 d}$ (2) increase by $\frac{3q^2}{4\pi\varepsilon_0 d}$

(3) decrease by $\frac{4q^2}{3\pi\varepsilon_0 d}$ (4) decrease by $\frac{q^2}{4\pi\varepsilon_0 d}$

ES0264

node06\B0BC-BD\Kota\JEE(Advanced)\Enthuse\Phy\Module\2-Electro-Gravi-Current Elec.-Capa\Eng\01_Electrostatics\01_Eng.p65

28. A solid sphere of radius R carries a charge (Q + q) distributed uniformly over its volume. A very small point like piece of it of mass m gets detached from the bottom of the sphere and falls down vertically under gravity. This piece carries charge q. If it acquires a speed v when it has fallen through a vertical height y (see figure), then : (assume the remaining portion to be spherical). **[JEE-Main-2020_Sep]**



(1) $v^2 = 2y\left[\frac{qQ}{4\pi\in_0 R(R+y)m} + g\right]$

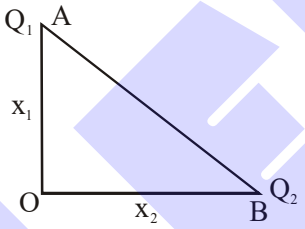
(2) $v^2 = y\left[\frac{qQ}{4\pi\in_0 R^2 ym} + g\right]$

(3) $v^2 = 2y\left[\frac{qQR}{4\pi\in_0 (R+y)^3 m} + g\right]$

(4) $v^2 = y\left[\frac{qQ}{4\pi\in_0 R(R+y)m} + g\right]$

ES0265

29. Charges Q_1 and Q_2 arc at points A and B of a right angle triangle OAB (see figure). The resultant electric field at point O is perpendicular to the hypotenuse, then Q_1/Q_2 is proportional to : **[JEE-Main-2020_Sep]**



(1) $\frac{x_2^2}{x_1^2}$

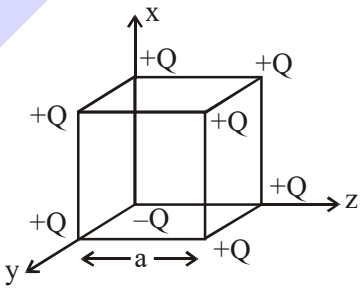
(2) $\frac{x_1^3}{x_2^3}$

(3) $\frac{x_1}{x_2}$

(4) $\frac{x_2}{x_1}$

ES0266

30. A cube of side 'a' has point charges +Q located at each of its vertices except at the origin where the charge is –Q. The electric field at the centre of cube is : **[JEE-Main-2021_Feb]**



(1) $\frac{-Q}{3\sqrt{3}\,\pi\varepsilon_0 a^2}(\hat{x}+\hat{y}+\hat{z})$

(2) $\frac{-2Q}{3\sqrt{3}\,\pi\varepsilon_0 a^2}(\hat{x}+\hat{y}+\hat{z})$

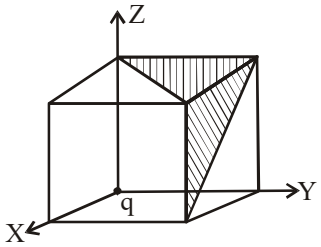
(3) $\frac{2Q}{3\sqrt{3}\,\pi\varepsilon_0 a^2}(\hat{x}+\hat{y}+\hat{z})$

(4) $\frac{Q}{3\sqrt{3}\,\pi\varepsilon_0 a^2}(\hat{x}+\hat{y}+\hat{z})$

ES0353

node06\B0BC-BD\Kota\JEE(Advanced)\Enthuse\Phy\Module\2.Electro-Grav+Current Elec.-Capa\Eng\01_Electrostatics\01_Eng.p65

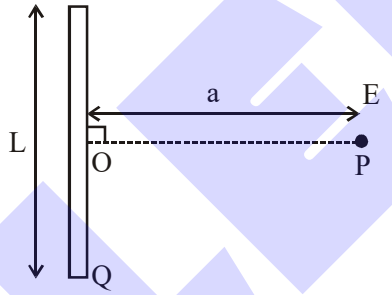
31. A charge 'q' is placed at one corner of a cube as shown in figure.The flux of electrostatic field $\vec{E}$ through the shaded area is : **[JEE-Main-2021_Feb]**



(1) $\frac{q}{4\varepsilon_0}$ (2) $\frac{q}{24\varepsilon_0}$ (3) $\frac{q}{48\varepsilon_0}$ (4) $\frac{q}{8\varepsilon_0}$

ES0354

32. Find the electric field at point P (as shown in figure) on the perpendicular bisector of a uniformly charged thin wire of length L carrying a charge Q. The distance of the point P from the centre of the rod is $a = \frac{\sqrt{3}}{2}L$. **[JEE-Main-2021_Feb]**



(1) $\frac{\sqrt{3}Q}{4\pi\varepsilon_0 L^2}$ (2) $\frac{Q}{3\pi\varepsilon_0 L^2}$ (3) $\frac{Q}{2\sqrt{3}\pi\varepsilon_0 L^2}$ (4) $\frac{Q}{4\pi\varepsilon_0 L^2}$

ES0355

33. Given below are two statements : **[JEE-Main-2021_Feb]**

Statement I : An electric dipole is placed at the centre of a hollow sphere. The flux of electric field through the sphere is zero but the electric field is not zero anywhere in the sphere.

Statement II : If R is the radius of a solid metallic sphere and Q be the total charge on it. The electric field at any point on the spherical surface of radius r (< R) is zero but the electric flux passing through this closed spherical surface of radius r is not zero.

In the light of the above statements, choose the correct answer from the options given below :

(1) Both Statement I and Statement II are true.

(2) Statement I is true but Statement II is false.

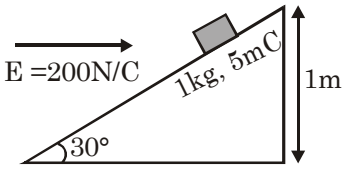
(3) Both Statement I and Statement II are false.

(4) Statement I is false but Statement II is true.

ES0356

node06\B0BC-BD\Kota\JEE(Advanced)\Enthuse\Phy\Module\2-Electro-Gravi-Current Elec.-Capa\Eng\01_Electrostatics\01_Eng.p65

34. An inclined plane making an angle of 30° with the horizontal is placed in a uniform horizontal electric field $200\frac{N}{C}$ as shown in the figure. A body of mass 1kg and charge 5 mC is allowed to slide down from rest at a height of 1m. If the coefficient of friction is 0.2, find the time taken by the body to reach the bottom.[g = 9.8 m/s^2, sin 30° = $\frac{1}{2}$; cos 30° = $\frac{\sqrt{3}}{2}$] **[JEE-Main-2021_Feb]**



(1) 0.92 s (2) 0.46 s (3) 2.3 s (4) 1.3 s

ES0357

35. An oil drop of radius 2 mm with a density 3g cm^{-3} is held stationary under a constant electric field 3.55×10^5 V m^{-1} in the Millikan's oil drop experiment. What is the number of excess electrons that the oil drop will possess ? (consider g = 9.81 m/s^2) **[JEE-Main-2021_March]**

(1) 48.8×10^{11} (2) 1.73×10^{10} (3) 17.3×10^{10} (4) 1.73×10^{12}

ES0358

36. An electric dipole is placed on x-axis in proximity to a line charge of linear charge density 3.0×10^{-6} C/m. Line charge is placed on z-axis and positive and negative charge of dipole is at a distance of 10 mm and 12 mm from the origin respectively. If total force of 4 N is exerted on the dipole, find out the amount of positive or negative charge of the dipole. **[JEE-Main-2021_July]**

(1) 815.1 nC (2) 8.8 μC (3) 0.485 mC (4) 4.44 μC

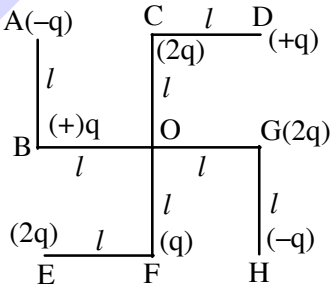
ES0359

37. The total charge enclosed in an incremental volume of 2×10^{-9} m^3 located at the origin is _____ nC, if electric flux density of its field is found as $D = e^{-x}\sin y\,\hat{i} - e^{-x}\cos y\,\hat{j} + 2z\hat{k}$ C/m^2.

[JEE-Main-2021_July]

ES0360

38. What will be the magnitude of electric field at point O as shown in figure? Each side of the figure is ℓ and perpendicular to each other? **[JEE-Main-2021_July]**



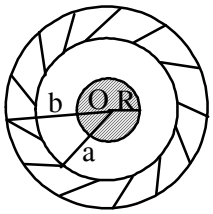
(1) $\frac{1}{4\pi\varepsilon_0}\frac{q}{l^2}$ (2) $\frac{1}{4\pi\varepsilon_0}\frac{q}{(2l^2)}\left(2\sqrt{2}-1\right)$

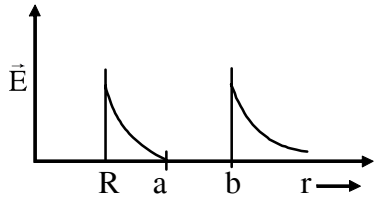
(3) $\frac{q}{4\pi\varepsilon_0(2l)^2}$ (4) $\frac{1}{4\pi\varepsilon_0}\frac{2q}{2l^2}\left(\sqrt{2}\right)$

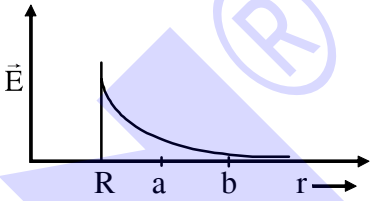
ES0361

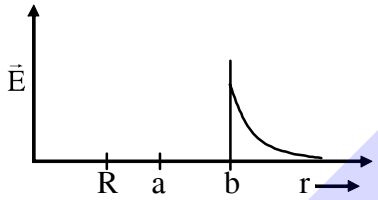
node06\B0BC-BD\Kota\JEE(Advanced)\Enthuse\Phy\Module\2.Electro-Grav+Current Elec.-Capa\Eng\01_Electrostatics\01_Eng.p65

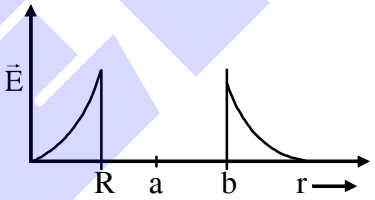
39. A solid metal sphere of radius R having charge q is enclosed inside the concentric spherical shell of inner radius a and outer radius b as shown in figure. The approximate variation electric field $\vec{E}$ as a function of distance r from centre O is given by **[JEE-Main-2021_Aug]**



(1)


(2)


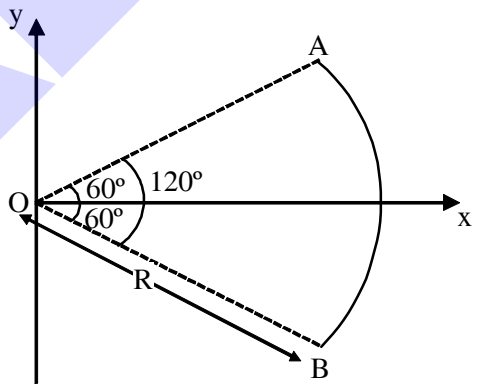
(3)


(4)


ES0362

40. Figure shows a rod AB, which is bent in a 120º circular arc of radius R. A charge (–Q) is uniformly distributed over rod AB. What is the electric field $\vec{E}$ at the centre of curvature O ?

[JEE-Main-2021_Aug]



(1) $\frac{3\sqrt{3}Q}{8\pi\varepsilon_0 R^2}\left(\hat{i}\right)$ (2) $\frac{3\sqrt{3}Q}{8\pi^2\varepsilon_0 R^2}\left(\hat{i}\right)$ (3) $\frac{3\sqrt{3}Q}{16\pi^2\varepsilon_0 R^2}\left(\hat{i}\right)$ (4) $\frac{3\sqrt{3}Q}{8\pi^2\varepsilon_0 R^2}\left(-\hat{i}\right)$

ES0363

node06\B0BC-BD\Kota\JEE(Advanced)\Enthuse\Phy\Module\2.Electro-Gravi-Current Elec.-Copy\Eng\01_Electrostatics\01_Eng.p65

41. Choose the incorrect statement : **[JEE-Main-2021_Aug]**

(a) The electric lines of force entering into a Gaussian surface provide negative flux.

(b) A charge 'q' is placed at the centre of a cube. The flux through all the faces will be the same.

(c) In a uniform electric field net flux through a closed Gaussian surface containing no net charge, is zero.

(d) When electric field is parallel to a Gaussian surface, it provides a finite non-zero flux.

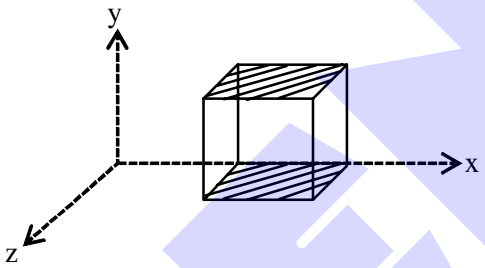
Choose the most appropriate answer from the options given below

(1) (c) and (d) only (2) (b) and (d) only

(3) (d) only (4) (a) and (c) only

ES0364

42. A cube is placed inside an electric field, $\vec{E} = 150y^2\hat{j}$. The side of the cube is 0.5 m and is placed in the field as shown in the given figure. The charge inside the cube is : **[JEE-Main-2021_Aug]**



(1) 3.8×10^{-11} C (2) 8.3×10^{-11} C

(3) 3.8×10^{-12} C (4) 8.3×10^{-12} C

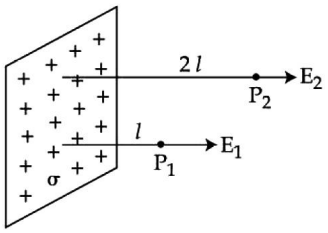
ES0365

43. A long cylindrical volume contains a uniformly distributed charge of density ρ. The radius of cylindrical volume is R. A charge particle (q) revolves around the cylinder in a circular path. The kinetic of the particle is : **[JEE-Main-2022_June]**

(A) $\frac{\rho q R^2}{4\varepsilon_0}$ (B) $\frac{\rho q R^2}{2\varepsilon_0}$ (C) $\frac{q\rho}{4\varepsilon_0 R^2}$ (D) $\frac{4\varepsilon_0 R^2}{q\rho}$

ES0366

44. In the figure, a very large plane sheet of positive charge is shown. P_1 and P_2 are two points at distance l and $2l$ from the charge distribution. If σ is the surface charge density, then the magnitude of electric fields E_1 and E_2 at P_1 and P_2 respectively are : **[JEE-Main-2022_June]**



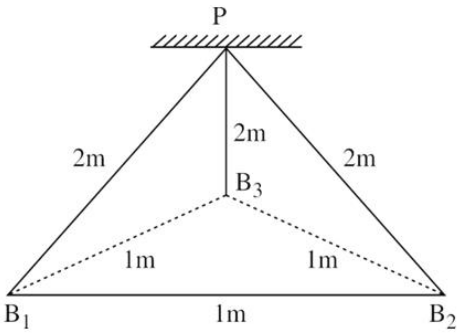
(A) $E_1 = \sigma/\varepsilon_0, E_2 = \sigma/2\varepsilon_0$ (B) $E_1 = 2\sigma/\varepsilon_0, E_2 = \sigma/\varepsilon_0$

(C) $E_1 = E_2 = \sigma/2\varepsilon_0$ (D) $E_1 = E_2 = \sigma/\varepsilon_0$

ES0367

node06\B0BC-BD\Kota\JEE(Advanced)\Enthuse\Phy\Module\2.Electro-Grav+Current Elec.-Capa\Eng\01_Electrostatics\01_Eng.p65

45. Three identical charged balls each of charge 2C are suspended from a common point P by silk threads of 2m each (as shown in figure). They form an equilateral triangle of side 1m. The ratio of net force on a charged ball to the force between any two charged balls will be : **[JEE-Main-2022_June]**



(A) 1 : 1 (B) 1 : 4 (C) $\sqrt{3}:2$ (D) $\sqrt{3}:1$

ES0368

46. If the electric potential at any point (x, y, z)m in space is given by $V = 3x^2$ volt. The electric field at the point (1, 0, 3) m will be : **[JEE-Main-2022_June]**

(A) 3 Vm^{-1}, directed along positive x-axis.
(B) 3 Vm^{-1}, directed along negative x-axis.
(C) 6 Vm^{-1}, directed along positive x-axis.
(D) 6 Vm^{-1}, directed along negative x-axis.

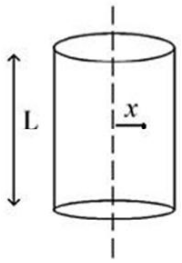
ES0369

47. Three point charges of magnitude 5μC, 0.16μC and 0.3 μC are located at the vertices A, B, C of a right angled triangle whose sides are AB = 3cm, $BC = 3\sqrt{2}$ cm and CA = 3 cm and point A is the right angle corner. Charge at point A experiences _____ N of electrostatic force due to the other two charges. **[JEE-Main-2022_July]**

ES0370

48. A long cylindrical volume contains a uniformly distributed charge of density ρ Cm^{-3}. The electric field inside the cylindrical volume at a distance $x = \frac{2\varepsilon_0}{\rho}$ m from its axis is _____ Vm^{-1}.

[JEE-Main-2022_July]



ES0371

node06\B0BC-BD\Kota\JEE(Advanced)\Enthuse\Phy\Module\2-Electro-Gravi-Current Elec.-Copy\Eng\01_Electrostatics\01_Eng.p65

49. Two electric dipoles of dipole moments 1.2×10^{-30} cm and 2.4×10^{-30} cm are placed in two difference uniform electric fields of strengths 5×10^4 NC^{-1} and 15×10^4 NC^{-1} respectively. The ratio of maximum torque experienced by the electric dipoles will be $\frac{1}{x}$. The value of x is _____.

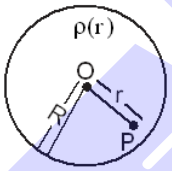
[JEE-Main-2022_July]

ES0372

50. A spherically symmetric charge distribution is considered with charge density varying as

$$\rho(r) = \begin{cases} \rho_0\left(\frac{3}{4} - \frac{r}{R}\right) & \text{for } r \le R \\ \text{Zero} & \text{for } r > R \end{cases}$$

Where, r(r < R) is the distance from the centre O (as shown in figure). The electric field at point P will be : **[JEE-Main-2022_July]**



(A) $\frac{\rho_0 r}{4\varepsilon_0}\left(\frac{3}{4} - \frac{r}{R}\right)$ (B) $\frac{\rho_0 r}{3\varepsilon_0}\left(\frac{3}{4} - \frac{r}{R}\right)$ (C) $\frac{\rho_0 r}{4\varepsilon_0}\left(1 - \frac{r}{R}\right)$ (D) $\frac{\rho_0 r}{5\varepsilon_0}\left(1 - \frac{r}{R}\right)$

ES0373

51. Two identical metallic spheres A and B when placed at certain distance in air repel each other with a force of F. Another identical uncharged sphere C is first placed in contact with A and then in contact with B and finally placed at midpoint between spheres A and B. The force experienced by sphere C will be : **[JEE-Main-2022_July]**

(A) 3F/2 (B) 3F/4 (C) F (D) 2F

ES0374

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EXERCISE-(JA)

1. Two non-conducting solid spheres of radii R and 2R, having uniform volume charge densities ρ_1 and ρ_2 respectively, touch each other. The net electric field at a distance 2R from the centre of the smaller sphere, along the line joining the centres of the spheres, is zero. The ratio $\frac{\rho_1}{\rho_2}$ can be

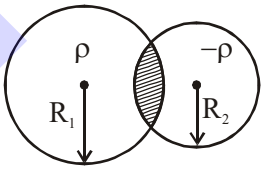
[JEE-Advance-2013]

(A) –4 (B) $-\frac{32}{25}$ (C) $\frac{32}{25}$ (D) 4

ES0217

2. Two non-conducting spheres of radii R_1 and R_2 and carrying uniform volume charge densities $+\rho$ and $-\rho$, respectively, are placed such that they partially overlap, as shown in the figure. At all points in the overlapping region :- **[JEE-Advance-2013]**

(A) the electrostatic field is zero
(B) the electrostatic potential is constant
(C) the electrostatic field is constant in magnitude
(D) the electrostatic field has same direction



ES0218

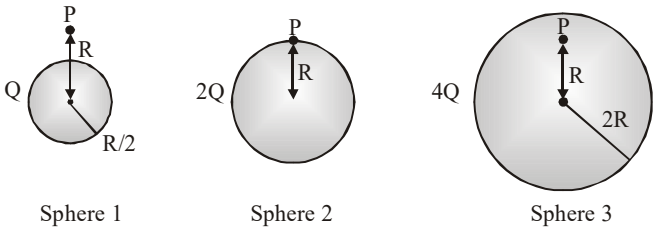
3. Let $E_1(r)$, $E_2(r)$ and $E_3(r)$ be the respective electric fields at a distance r from a point charge Q, an infinitely long wire with constant linear charge density λ, and an infinite plane with uniform surface charge density σ. If $E_1(r_0) = E_2(r_0) = E_3(r_0)$ at a given distance r_0, then :- **[JEE-Advance-2014]**

(A) $Q = 4\sigma\pi r_0^2$ (B) $r_0 = \frac{\lambda}{2\pi\sigma}$

(C) $E_1(r_0/2) = 2E_2(r_0/2)$ (D) $E_2(r_0/2) = 4E_3(r_0/2)$

ES0219

4. Charges Q, 2Q and 4Q are uniformly distributed in three dielectric solid spheres 1, 2 and 3 of radii R/2, R and 2R respectively, as shown in figure. If magnitudes of the electric fields at point P at a distance R from the centre of spheres 1, 2 and 3 are E_1, E_2 and E_2 respectively, then **[JEE-Advance-2014]**



Sphere 1 Sphere 2 Sphere 3

(A) $E_1 > E_2 > E_3$ (B) $E_3 > E_1 > E_2$ (C) $E_2 > E_1 > E_3$ (D) $E_3 > E_2 > E_1$

ES0220

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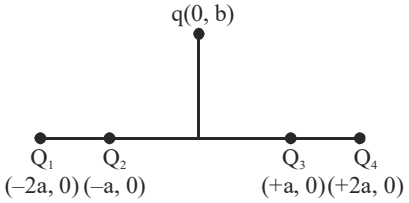
5. Four charges Q_1, Q_2, Q_3 and Q_4 of same magnitude are fixed along the x axis at x = –2a, –a, +a and +2a, respectively. A positive charge q is placed on the positive y axis at a distance b > 0. Four options of the signs of these charges are given in List I. The direction of the forces on the charge q is given in List II. Match List I with List II and select the correct answer using the code given below the lists.

[JEE-Advance-2014]



	List-I		**List-II**
(P)	Q_1, Q_2, Q_3, Q_4 all positive	(1)	+x
(Q)	Q_1, Q_2 positive ; Q_3, Q_4 negative	(2)	–x
(R)	Q_1, Q_4 positive ; Q_2, Q_3 negative	(3)	+y
(S)	Q_1, Q_3 positive ; Q_2, Q_4 negative	(4)	–y

Code :

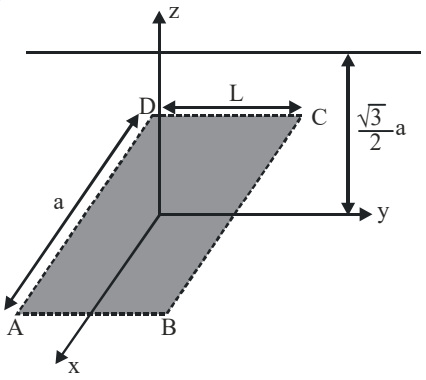
(A) P-3, Q-1, R-4, S-2 (B) P-4, Q-2, R-3, S-1

(C) P-3, Q-1, R-2, S-4 (D) P-4, Q-2, R-1, S-3

ES0221

6. An infinitely long uniform line charge distribution of charge per unit length λ lies parallel to the y-axis in the y-z plane at $z = \frac{\sqrt{3}}{2}a$ (see figure). If the magnitude of the flux of the electric field through the rectangular surface ABCD lying in the x-y plane with its centre at the origin is $\frac{\lambda L}{n\varepsilon_0}$ (ε_0 = perimittivity of free space) then the value of n is.

[JEE-Advance-2015]



ES0222

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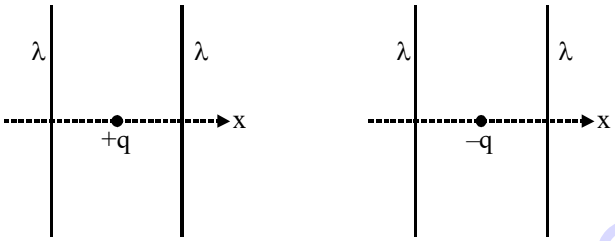
7. The figures below depict two situations in which two infinitely long static line charges of constant positive line charge density λ are kept parallel to each other. In their resulting electric field, point charges q and –q are kept in equilibrium between them .The point charges are confined to move in the x direction only. If they are given a small displacement about their equlibrium positions, then the correct statement(s) is (are) : **[JEE-Advance-2015]**

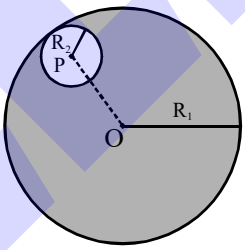


(A) Both charges execute simple harmonic motion
(B) Both charges will continue moving in the direction of their displacement
(C) Charge +q executes simple harmonic motion while charge –q continues moving in the direction of its displacement.
(D) Charge –q executes simple harmonic motion while charge +q continues moving in the direction of its displacement.

ES0223

8. Consider a uniform spherical distirbution of radius R_1 centred at the origin O. In this distibution, a spherical cavity of radius R_2, centred at P with distance OP = a = $R_1 - R_2$ (see figure) is made. If the electric field inside the cavity at position $\vec{r}$ is $\vec{E}(\vec{r})$, then the correct statement(s) is(are) :

[JEE-Advance-2015]



(A) $\vec{E}$ is uniform, its magnitude is independent of R_2 but its direction depends on $\vec{r}$
(B) $\vec{E}$ is uniform, its magnitude depends on R_2 and its direction depends on $\vec{r}$
(C) $\vec{E}$ is uniform, its magnitude is independent of a but its direction depends on $\vec{a}$
(D) $\vec{E}$ is uniform and both its magnitude and direction depend on $\vec{a}$

ES0224

9. A length-scale (ℓ) depends on the permittivity (ε) of a dielectric material, Boltzmann constant k_B, the absolute temperature T, the number per unit volume (n) of certain charged particles, and the charge (q) carried by each of the particles, Which of the following expressions(s) for ℓ is(are) dimensionally correct? **[JEE-Advance-2016]**

(A) $\ell = \sqrt{\left(\frac{nq^2}{\varepsilon k_B T}\right)}$ (B) $\ell = \sqrt{\left(\frac{\varepsilon k_B T}{nq^2}\right)}$ (C) $\ell = \sqrt{\left(\frac{q^2}{\varepsilon n^{2/3} k_B T}\right)}$ (D) $\ell = \sqrt{\left(\frac{q^2}{\varepsilon n^{1/3} k_B T}\right)}$

ES0225

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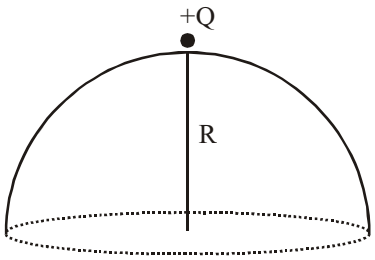
10. A point charge +Q is placed just outside an imaginary hemispherical surface of radius R as shown in the figure. Which of the following statements is/are correct ? **[JEE-Advance-2017]**



(A) The circumference of the flat surface is an equipotential

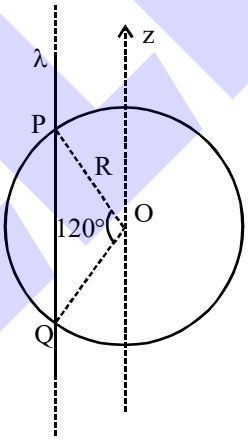
(B) The electric flux passing through the curved surface of the hemisphere is $-\frac{Q}{2\varepsilon_0}\left(1-\frac{1}{\sqrt{2}}\right)$

(C) Total flux through the curved and the flat surfaces is $\frac{Q}{\varepsilon_0}$

(D) The component of the electric field normal to the flat surface is constant over the surface.

ES0226

11. An infinitely long thin non-conducting wire is parallel to the z-axis and carries a uniform line charge density λ. It pierces a thin non-conducting spherical shell of radius R in such a way that the arc PQ subtends an angle 120° at the centre O of the spherical shell, as shown in the figure. The permittivity of free space is ε_0. Which of the following statements is (are) true ? **[JEE-Advance-2018]**



(A) The electric flux through the shell is $\sqrt{3}\,R\lambda/\varepsilon_0$

(B) The z-component of the electric field is zero at all the points on the surface of the shell

(C) The electric flux through the shell is $\sqrt{2}\,R\lambda/\varepsilon_0$

(D) The electric field is normal to the surface of the shell at all points

ES0227

12. A particle, of mass 10^{-3} kg and charge 1.0 C, is initially at rest. At time t = 0, the particle comes under the influence of an electric field $\vec{E}(t) = E_0 \sin \omega t\, \hat{i}$ where $E_0 = 1.0$ N C^{-1} and $\omega = 10^3$ rad s^{-1}. Consider the effect of only the electrical force on the particle. Then the maximum speed, in ms^{-1}, attained by the particle at subsequent times is..... **[JEE-Advance-2018]**

ES0228

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13. The electric field E is measured at a point P(0,0,d) generated due to various charge distributions and the dependence of E on d is found to be different for different charge distributions. List-I contains different relations between E and d. List-II describes different electric charge distributions, along with their locations. Match the functions in List-I with the related charge distributions in List-II.

[JEE-Advance-2018]

	List–I		**List–II**
P.	E is indpendent of d	1.	A point charge Q at the origin
Q.	$E \propto \frac{1}{d}$	2.	A small dipole with point charges Q at $(0,0,\ell)$ and – Q at $(0,0,-\ell)$. Take $2\ell << d$
R.	$E \propto \frac{1}{d^2}$	3.	An infinite line charge coincident with the x-axis, with uniform linear charge density λ.
S.	$E \propto \frac{1}{d^3}$	4.	Two infinite wires carrying uniform linear Charge density parallel to the x - axis. The one along $(y = 0, z = \ell)$ has a charge density $+\lambda$ and the one along $(y = 0, z = -\ell)$ has a charge density $-\lambda$. Take $2\ell << d$
		5.	Infinite plane charge coincident with the xy-plane with uniform surface charge density

(A) P → 5 ; Q → 3, 4 ; R → 1 ; S → 2
(B) P → 5 ; Q → 3, ; R → 1,4 ; S → 2
(C) P → 5 ; Q → 3, ; R → 1,2 ; S → 4
(D) P → 4 ; Q → 2, 3 ; R → 1 ; S → 5

ES0229

14. A thin spherical insulating shell of radius R carries a uniformly distributed charge such that the potential at its surface is V_0. A hole with a small area $\alpha 4\pi R^2$ ($\alpha << 1$) is made on the shell without affecting the rest of the shell. Which one of the following statements is correct ?

[JEE-Advance-2019]

(1) The ratio of the potential at the center of the shell to that of the point at $\frac{1}{2}R$ from center towards the hole will be $\frac{1-\alpha}{1-2\alpha}$

(2) The magnitude of electric field at the center of the shell is reduced by $\frac{\alpha V_0}{2R}$

(3) The magnitude of electric field at a point, located on a line passing through the hole and shell's center on a distance 2R from the center of the spherical shell will be reduced by $\frac{\alpha V_0}{2R}$

(4) The potential at the center of the shell is reduced by $2\alpha V_0$

ES0230

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15. A charged shell of radius R carries a total charge Q. Given Φ as the flux of electric field through a closed cylindrical surface of height h, radius r and with its center same as that of the shell. Here, center of the cylinder is a point on the axis of the cylinder which is equidistant from its top and bottom surfaces. Which of the following option(s) is/are correct ? [$\in_0$ is the permittivity of free space] **[JEE-Advance-2019]**

(1) If h > 2R and r > R then $\Phi = \frac{Q}{\in_0}$

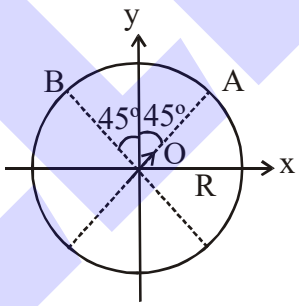
(2) If $h < \frac{8R}{5}$ and $r = \frac{3R}{5}$ then $\Phi = 0$

(3) If h > 2R and $r = \frac{4R}{5}$ then $\Phi = \frac{Q}{5 \in_0}$

(4) If h > 2R and $r = \frac{3R}{5}$ then $\Phi = \frac{Q}{5 \in_0}$

ES0231

16. An electric dipole with dipole moment $\frac{p_0}{\sqrt{2}}(\hat{i}+\hat{j})$ is held fixed at the origin O in the presence of an uniform electric field of magnitude E_0. If the potential is constant on a circle of radius R centered at the origin as shown in figure, then the correct statement(s) is/are:
(ε_0 is permittivity of free space, R >> dipole size) **[JEE-Advance-2019]**



(1) $R = \left(\frac{p_0}{4\pi\varepsilon_0 E_0}\right)^{1/3}$

(2) The magnitude of total electric field on any two points of the circle will be same

(3) Total electric field at point A is $\vec{E}_A = \sqrt{2}E_0(\hat{i}+\hat{j})$

(4) Total electric field at point B is $\vec{E}_B = 0$

ES0232

17. A uniform electric field, $\vec{E} = -400\sqrt{3}\hat{y}$ NC^{-1} is applied in a region. A charged particle of mass m carrying positive charge q is projected in this region with an initial speed of $2\sqrt{10} \times 10^6$ ms^{-1}. This particle is aimed to hit a target T, which is 5 m away from its entry point into the field as shown schematically in the figure. Take $\frac{q}{m} = 10^{10}$ Ckg^{-1}. Then:- **[JEE-Advance-2020]**

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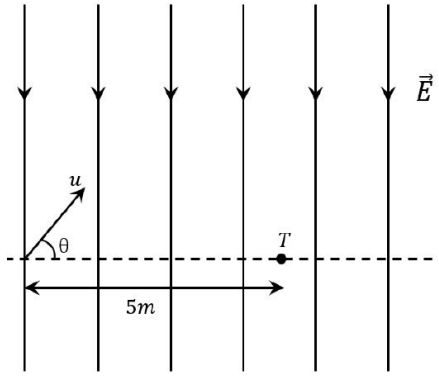


(A) the particle will hit T if projected at an angle 45° from the horizontal

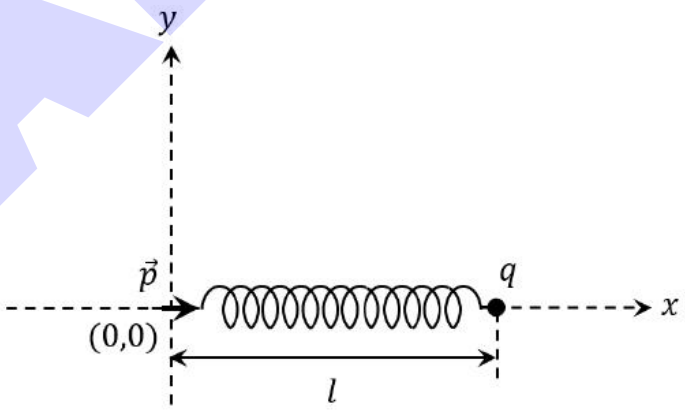
(B) the particle will hit T if projected either at an angle 30° or 60° from the horizontal

(C) time taken by the particle to hit T could be $\sqrt{\frac{5}{6}}$ μs as well as $\sqrt{\frac{5}{2}}$ μs

(D) time taken by the particle to hit T is $\sqrt{\frac{5}{3}}$ μs

ES0267

18. One end of a spring of negligible unstretched length and spring constant k is fixed at the origin (0,0). A point particle of mass m carrying a positive charge q is attached at its other end. The entire system is kept on a smooth horizontal surface. When a point dipole $\vec{p}$ pointing towards the charge q is fixed at the origin, the spring gets stretched to a length ℓ and attains a new equilibrium position (see figure below). If the point mass is now displaced slightly by $\Delta\ell << \ell$ from its equilibrium position and released, it is found to oscillate at frequency $\frac{1}{\delta}\sqrt{\frac{k}{m}}$. The value of δ is. **[JEE-Advanced-2020]**



ES0268

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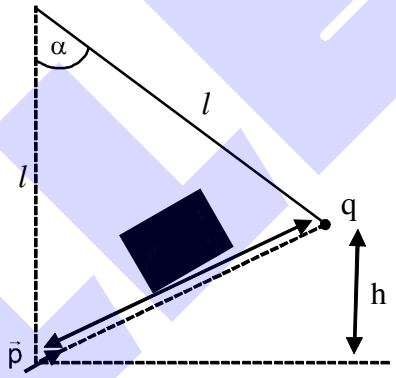
19. A circular disc of radius R carries surface charge density $\sigma(r) = \sigma_0\left(1-\frac{r}{R}\right)$, where σ_0 is a constant and r is the distance from the center of the disc. Electric flux through a large spherical surface that encloses the charged disc completely is ϕ_0. Electric flux through another spherical surface of radius $\frac{R}{4}$ and concentric with the disc is ϕ. Then the ratio $\frac{\phi_0}{\phi}$ is_____. - **[JEE-Advance-2020]**

ES0269

20. A point charge q of mass m is suspended vertically by a string of length ℓ. A point dipole of dipole moment $\vec{p}$ is now brought towards q from infinity so that the charge moves away. The final equilibrium position of the system including the direction of the dipole, the angles and distances is shown in the figure below. If the work done in bringing the dipole to this position is N × (mgh), where g is the acceleration due to gravity, then the value of N is _____. (Note that for three coplanar forces keeping a point mass in equilibrium, $\frac{F}{\sin\theta}$ is the same for all forces, where F is any one of the forces and θ is the angle between the other two forces) **[JEE-Advance-2020]**



ES0270

21. Two identical non-conducting solid spheres of same mass and charge are suspended in air from a common point by two non-conducting, massless strings of same length. At equilibrium, the angle between the strings is α. The spheres are now immersed in a dielectric liquid of density 800 kg m^{-3} and dielectric constant 21. If the angle between the strings remains the same after the immersion, then **[JEE-Advance-2020]**

(A) electric force between the spheres remains unchanged

(B) electric force between the spheres reduces

(C) mass density of the spheres is 840 kg m^{-3}

(D) the tension in the strings holding the spheres remains unchanged

ES0271

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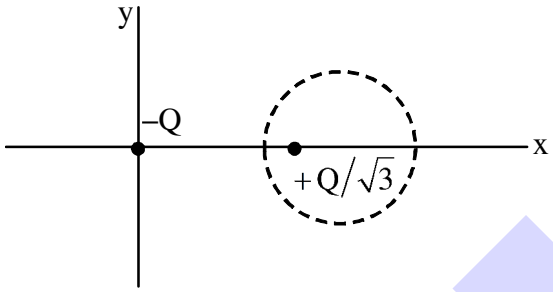
Question Stem for Question Nos. 22 and 23

Question Stem

Two point charges –Q and $+Q/\sqrt{3}$ are placed in the xy-plane at the origin (0, 0) and a point (2, 0), respectively, as shown in the figure. This results in an equipotential circle of radius R and potential V = 0 in the xy-plane with its center at (b, 0). All lengths are measured in meters.

[JEE-Advance-2021]



22. The value of R is ___ meter.

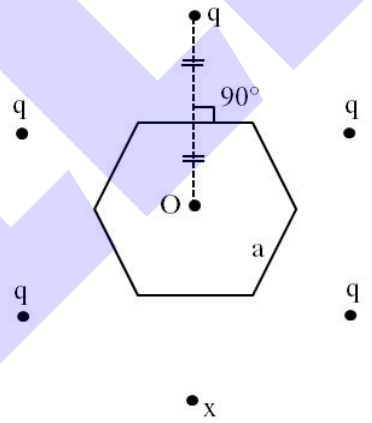
ES0272

23. The value of b is ___ meter.

ES0273

24. Six charges are placed around a regular hexagon of side length a as shown in the figure. Five of them have charge q, and the remaining one has charge x. The perpendicular from each charge to the nearest hexagon side passes through the center O of the hexagon and is bisected by the side.

[JEE-Advance-2022]



Which of the following statement(s) is(are) correct in SI units?

(A) When x = q, the magnitude of the electric field at O is zero.

(B) When x = –q, the magnitude of the electric field at O is $\frac{q}{6\pi \in_0 a^2}$.

(C) When x = 2q, the potential at O is $\frac{7q}{4\sqrt{3}\pi \in_0 a}$.

(D) When x = –3q, the potential at O is $\frac{3q}{4\sqrt{3}\pi \in_0 a}$.

ES0375

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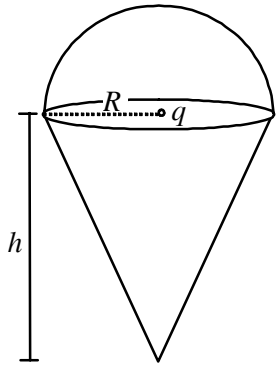
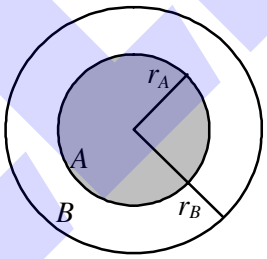
25. A charge q is surrounded by a closed surface consisting of an inverted cone of height h and base radius R, and a hemisphere of radius R as shown in the figure. The electric flux through the conical surface is $\frac{nq}{6\epsilon_0}$ (in SI units). The value of n is _____. **[JEE-Advance-2022]**



ES0376

26. In the figure, the inner (shaded) region A represents a sphere of radius $r_A = 1$, within which the electrostatic charge density varies with the radial distance r from the center as $\rho_A = kr$, where k is positive. In the spherical shell B of outer radius r_B, the electrostatic charge density varies as $\rho_B = \frac{2k}{r}$. Assume that dimensions are taken care of. All physical quantities are in their SI units.

[JEE-Advance-2022]



Which of the following statement(s) is(are) correct?

(A) If $r_B = \sqrt{\frac{3}{2}}$, then the electric field is zero everywhere outside B.

(B) If $r_B = \frac{3}{2}$, then the electric potential just outside B is $\frac{k}{\epsilon_0}$.

(C) If $r_B = 2$, then the total charge of the configuration is $15\pi k$.

(D) If $r_B = \frac{5}{2}$, then the magnitude of the electric field just outside B is $\frac{13\pi k}{\epsilon_0}$.

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27. A disk of radius R with uniform positive charge density σ is placed on the xy plane with its center at the origin. The Coulomb potential along the z-axis is

$$V(z)=\frac{\sigma}{2\in_0}\left(\sqrt{R^2+z^2}-z\right)$$

A particle of positive charge q is placed initially at rest at a point on the z axis with $z = z_0$ and $z_0 > 0$. In addition to the Coulomb force, the particle experiences a vertical force $\vec{F}=-c\hat{k}$ with $c > 0$. Let $\beta=\frac{2c\in_0}{q\sigma}$. Which of the following statement(s) is(are) correct? **[JEE-Advance-2022]**

(A) For $\beta=\frac{1}{4}$ and $z_0=\frac{25}{7}R$, the particle reaches the origin.

(B) For $\beta=\frac{1}{4}$ and $z_0=\frac{3}{7}R$, the particle reaches the origin.

(C) For $\beta=\frac{1}{4}$ and $z_0=\frac{R}{\sqrt{3}}$, the particle returns back to $z = z_0$.

(D) For $\beta > 1$ and $z_0 > 0$, the particle always reaches the origin.

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ANSWER KEY

EXERCISE # O-1

Que.	1	2	3	4	5	6	7	8	9	10
Ans.	C	B	B	D	A	C	C	B	B	C
Que.	11	12	13	14	15	16	17	18	19	20
Ans.	B	C	B	D	D	C	B	A	C	A
Que.	21	22	23	24	25	26	27	28	29	30
Ans.	C	C	D	B	D	C	A	A	D	A
Que.	31	32	33	34	35	36	37	38	39	40
Ans.	C	C	D	D	D	B	D	B	A	B
Que.	41	42	43	44	45	46	47	48	49	50
Ans.	A	A	B	A	B	C	D	B	C	A
Que.	51	52	53	54	55	56	57	58	59	60
Ans.	D	D	A	A	D	B	C	D	A	A
Que.	61	62	63	64	65	66	67	68	69	70 (a)
Ans.	D	D	A	B	D	D	A	D	A	B
Que.	70 (b)	71	72	73	74	75	76	77	78	79
Ans.	D	A	A	D	A	C	C	A	C	D
Que.	80	81								
Ans.	A	D								

EXERCISE # O-2

Que.	1	2	3	4	5	6	7	8	9	10
Ans.	C	B	A	C	D	A	C	A	B	C
Que.	11	12	13	14	15	16	17	18	19	20
Ans.	D	D	C	A	D	C	C	D	C	D
Que.	21	22	23	24	25	26	27	28	29	30
Ans.	B	C	D	A	D	C	A	C	A	C
Que.	31	32	33	34	35	36	37	38	39	40
Ans.	B	B	B	B	B	A	C	C	C	B
Que.	41	42	43	44	45	46	47	48	49	50
Ans.	B	A	C	B	C	C	A,B,C	A,B,D	A,C,D	A,B,C
Que.	51	52	53	54	55	56	57	58	59	60
Ans.	B,D	A,C,D	A,D	B,C,D	A,B,C	C,D	A,B,C	A,C	A,D	C
Que.	61	62	63	64	65	(A)	(B)	(C)	(D)	
Ans.	B	A	C	A		Q,R	Q,T	S,T	P	
Que.	66	(A)	(B)	(C)	(D)					
Ans.		Q	P,S	P,Q,R	Q,R					

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EXERCISE # S

1. 80 **2.** 3 **3.** 3 **4.** 4 **5.** 9.30 **6.** 3

7. 8 **8.** 6 **9.** 3 **10.** 4 **11.** $\frac{q}{24\varepsilon_0}$ **12.** 6

13. 2 **14.** 2 **15.** $2\tan^{-1}\left(\frac{\sigma q}{2\varepsilon_0 mg}\right)$ **16.** $\left[\frac{2KQq}{mR}\left(\frac{r-R}{r}+\frac{3}{8}\right)\right]^{1/2}$

17. 2 **18.** $\frac{kP}{\sqrt{2}\,y^3}(-\hat{i}-2\hat{j})$ **19.** 4

20. (a) K.E $=\frac{P}{4\pi\varepsilon_0}\frac{Q}{d^2}$, (b) $\frac{QP}{2\pi\varepsilon_0 d^3}$ along positive x-axis **21.** –Q/3

22. –εE,εE and so on

EXERCISE # JEE-MAIN

Que.	1	2	3	4	5	6	7	8	9	10
Ans.	2	1	4	1	1 or 2	3	2	1	1	4
Que.	11	12	13	14	15	16	17	18	19	20
Ans.	4	By NTA (1 or 3) By Allen 3	1	4	1	4	1	2	3	1
Que.	21	22	23	24	25	26	27	28	29	30
Ans.	2	4	4	3	1	1	3	1	3	2
Que.	31	32	33	34	35	36	37	38	39	40
Ans.	2	3	2	4	2	4	4	2	1	2
Que.	41	42	43	44	45	46	47	48	49	50
Ans.	3	2	A	C	D	D	17	1	6	C
Que.	51									
Ans.	B									

EXERCISE # JEE-ADVANCED

Que.	1	2	3	4	5	6	7	8	9	10
Ans.	B,D	C,D	C	C	A	6	C	D	B,D	A,B
Que.	11	12	13	14	15	16	17	18	19	20
Ans.	A,B	2 [1.99, 2.01]	B	1	1,2,4	1,4	B,C	3.14	6.40	2
Que.	21	22	23	24	25	26	27			
Ans.	B,C	1.73	3.00	A,B,C	3	B	A,C,D			

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Important Notes

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